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TECHNICAL GUIDE FOR REVIEW AND EVALUATION OF COMPLIANCE SCHEDULES FOR AIR POLLUTION SOURCES

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Estimates are given of time periods which are as expeditious as practicable for applying reasonably available control technology, including process modifications as well as add-on control devices or equipment, to various air pollution source categories. Process descriptions are given for the sources. These model compliance schedules indicate time periods required for completing increments of progress and achieving milestones as required by 40 CFR 51.15. Schedules are given for 34 industries in the following source categories: stationary combustion, solid waste disposal, evaporation sources, chemical processes, agricultural products, primary metallurgical processes, secondary metallurgical processes, mineral industries, petroleum industry, pulp and paper.

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by

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Cincinnati, Ohio 45246

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Mrs. Anne Cassel conducted the editorial review and Mr. Chuck Fleming was responsible for the graphics and final report preparation.

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1.0 INTRODUCTION

On August 14, 1971, the Administrator of the Environmental Protection Agency promulgated regulations in the Federal Register, 40 CFR Part 51, specifying minimum requirements for the State Air Quality Implementation Plans required by Section 110 of the Clean Air Act. As mandated by Section 110 and specified in these regulations, implementation plans must include emission limitations adequate to attain and maintain national ambient air quality standards and require compliance schedules from all sources subject to the emission limitations. These schedules must provide for compliance as expeditiously as practicable for sources in air quality control regions where the national primary standards are being exceeded or within a reasonable period of time for sources in regions where only the secondary air quality standards are being exceeded.

To provide aid for use in evaluating compliance schedules, this study was undertaken to determine the time required to install air pollution control equipment in an expeditious manner on selected industrial sources. The results of this study can also be used to develop federal compliance schedules where states have failed to submit approvable schedules to EPA. In addition, this study should prove useful to the EPA

Regional Offices developing schedules to be included in enforcement orders issued to air pollution sources under the authority of Section 113 of the Clean Air Act.

Industries selected for this study were chosen from those listed in Appendix C, 40 CFR, Part 51, and from those listed in the "Compilation of Air Pollution Emission Factors" published by the EPA Office of Air Programs. From these listings, industries were selected which met all three of the following criteria: (1) emit particulates, sulfur dioxide, nitrogen oxides, carbon monoxide, or hydrocarbons; (2) could achieve compliance with application of reasonably available control technology within a 36-month period; and (3) were significant on a nationwide basis both with respect to emissions potential and number of sources. Thirty-four industries were selected by application of these criteria, and schedules were prepared indicating the time required to control major emission sources within each industry to levels consistent with available control technology as defined in Appendix B, 40 CFR, Part 51.

Manufacturers and users of air pollution control equipment supplied most of the information used to develop the schedules. Three of the manufacturers -- Research Cottrell, Buell Envirotech, and Vulcan-Cincinnati -- also provided detailed case histories.

Preliminary schedules prepared using the manufacturers' data were subjected to engineering evaluation. The resulting tentative schedules were reviewed with representatives from the concerned industries and with EPA personnel. On the basis of these reviews, the schedules presented herein were developed.

It is emphasized that these schedules should be considered as guidelines. Many mitigating factors can affect the schedule of any individual installation. These factors include on-site problems such as space limitations, inclement weather, and lack of needed utilities; logistical problems such as delays in equipment delivery caused by special orders, backlog of orders, and unavailability of large motors and/or fans; and design problems caused by lack of engineering data for some applications. To the limited extent possible, such factors were considered in preparation of the schedules.

Section 2.0 describes the compliance schedule format, presents summary schedules by type of control device, and describes the technical and economic contingencies that can affect installations. Section 3.0 presents brief process descriptions and describes emission sources and emission characteristics for each of the thirty-four industries studied.

The types of control systems commonly used are identified, and some of the problems encountered in achieving reliable, high-efficiency emissions control are briefly discussed; sources of additional information are also listed. Time schedules are presented for installation of selected control methods. Section 4.0 describes the study approach and summarizes the supporting data used to prepare the schedules.

2.0 COMPLIANCE SCHEDULE DEVELOPMENT

2.1 Compliance Schedule Format

Figure 2.1 depicts the chart used to identify the various steps required to complete installation of a control system and the time required for such steps. The increments of progress (milestones) presented on this chart are the same as those defined in 40 CFR, Part 51:

(1) Date of submittal of the final control plan to the appropriate air pollution control agency;

(2) Date by which contracts for emission control systems or process modifications will be awarded; or date by which orders will be issued for purchase of component parts to accomplish emission control or process modification;

(3) Date of initiation of on-site construction or installation of emission control equipment or process change;

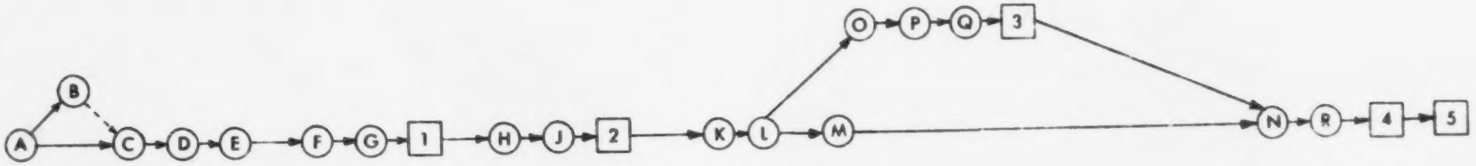
(4) Date by which on-site construction or installation of emission control equipment or process modification is to be completed; and

(5) Date by which final compliance is to be achieved.

The activities required for achieving these milestones, also shown on the compliance schedules chart, are described in Table 2.1.

In development of the time schedules, it was assumed that the steps prior to Milestone 1 are essentially completed. Since emission regulations were generally adopted in early 1972,

Figure 2.1 Compliance schedule chart.



☐ = Milestones

$\xrightarrow{2}$ = Activity and duration in weeks

MILESTONES		ELAPSED TIME (WEEKS)
1	Date of submittal of final control plan to appropriate agency.	______
2	Date of award of control device contract.	______
3	Date of initiation of on-site construction or installation of emission control equipment.	______
4	Date by which on-site construction or installation of emission control equipment is completed.	______
5	Date by which final compliance is achieved.	______

ACTIVITIES

Designation	
A-C	Preliminary investigation
A-B	Source tests
C-D	Evaluate control alternatives
D-E	Commit funds for total program
E-F	Prepare preliminary control plan and compliance schedule for agency
F-G	Agency review and approval
G-1	Finalize plans and specifications
1-H	Procure control device bids
H-J	Evaluate control device bids
J-2	Award control device contract
2-K	Vendor prepares assembly drawings

Designation	
K-L	Review and approval of assembly drawings
L-M	Vendor prepares fabrication drawings
M-N	Fabricate control device
L-O	Prepare engineering drawings
O-P	Procure construction bids
P-Q	Evaluate construction bids
Q-3	Award construction contract
3-N	On-site construction
N-R	Install control device
R-4	Complete construction (system tie-in)
4-5	Startup, shakedown, preliminary source test

Table 2.1 DESCRIPTION OF ACTIVITIES ON COMPLIANCE SCHEDULE CHART

ACTIVITY CODE	ACTIVITY DESCRIPTION	DETAILS OF ACTIVITY
G-1	Finalize plans and specification	The control system is specified in sufficient detail for control equipment suppliers and contractors to prepare bids. A final control plan summarizing this information is prepared for submittal to the appropriate agency.
I-H	Procure control device bids	Specifications for the control device are disseminated and bids from suppliers are requested.
H-J	Evaluate control device bids	Bids are evaluated and suppliers are selected.
J-2	Award control device contract	The successful bidder is notified and contract is signed.
2-K	Vendor prepares assembly drawings	The vendor prepares the assembly drawings for the control device. For the smaller and common types of devices, standard shop drawings which apply to several size ranges may be used with the appropriate dimensions underlined or otherwise indicated. For larger devices, it may be necessary to prepare drawings specifically for the project at hand. The drawings are mailed to the client for his approval before fabrication drawings are started.
K-L	Review and approval of assembly drawings	The client reviews the assembly drawings and gives approval to begin fabrication drawings. The client also uses the assembly drawings to prepare the necessary engineering drawings.
L-M	Vendor prepares fabrication drawings	Upon receipt of approval from client to proceed with construction of the control device, the vendor prepares fabrication or shop drawings which will be used in the manufacturing and assembling of the control equipment.
L-O	Prepare engineering drawings	Based on data from the vendor's drawings and previous engineering studies, the client (or his consultant) prepares architectural and mechanical drawings for modifications and additions to the plant to accommodate the emission control system.
O-P	Procure construction bids	The bid package specifying the scope of work and specifications of materials and including the drawings is mailed to selected contractors. During this period, the contractors prepare their bids for material and labor to construct all duct work, piping, utilities, etc. and for installation of the control device.

Table 2.1 (Continued)

ACTIVITY CODE	ACTIVITY DESCRIPTION	DETAILS OF ACTIVITY
P-Q	Evaluate construction bids	The client or his consultant evaluates the bids and selects the contractor.
Q-3	Award construction contract	The selected contractor is notified and the contract signed.
3-N	On-site construction	Using the architectural and mechanical drawings, the contractor begins his work. He usually subcontracts electrical or duct work to specialists.
N-4	Install control device	The control device (or the final components) arrives on site. The contractor should be prepared for installation and tie-in with other piping, duct work, and electrical switch gear. Field assembled units will arrive in sections and be erected at the site. Internals such as catalysts, activated carbon, and bag filters are also installed during this time.
R-4	Complete construction (system tie-in)	Tying the control device into the system requires shutdown of the process be scheduled for minimum disturbance of the operation. The contractor's responsibility usually ends at this point, when the client and the vendor's representative accept the construction as complete.
4-5	Startup, shakedown, emissions test	The process is brought back on-line and any unforeseen problems with the control system are resolved. Emissions testing may be performed to determine whether performance of the system is acceptable.

industries have had ample time to complete their problem evaluations, emission tests, and technical and economic evaluations of control alternatives. Thus the time schedules were started at the point of finalizing control system plans and specifications for submission to the appropriate air pollution control agency.

Table 2.2 identifies the typical times required to complete the various activities on the schedule and the factors that influence these times.

2.2 Summary Schedules by Control Device

Schedules for the expeditious installation of the most commonly used air pollution control devices are shown in Figures 2.2 through 2.12. Several sources of information were used to prepare these schedules. Promised delivery and installation times stated by control device suppliers were cross-checked with companies having recently purchased such equipment. In many cases, promised delivery times were not met. Analysis of case-history data provided by three control device manufacturers substantiated the need for modifying the "promised" or expected schedules currently quoted by vendors. On the other hand, case-history data also required qualification, since it did not reflect expeditious schedules, partly because of lack of enforcement

Table 2.2 COMPLIANCE SCHEDULE REQUIREMENTS
EXPLANATION OF ACTIVITIES ON CHART

ACTIVITY	COMMENTS
G-1	Two to six weeks are allocated for finalizing plans and specifications. The variation depends on the magnitude and complexity of the project.
1-H	A minimum time of four weeks is required to procure bids on small jobs. A maximum of twelve weeks is allowed for large non-standard units since initial vendor quotations frequently do not match bid specifications, and further contacts with each bidder are required.
H-J	Two to five weeks is allocated for evaluating control device bids. Small, privately owned firms will require little time; in large corporations, bid evaluation often involves several departments and more time is required.
J-2	A minimum of two weeks is allocated for preparing the final control papers and awarding contracts for the control device and major components. This activity takes longer in large corporations where examination and approval of the contract by several departments is required.
2-K	Depending on the complexity and originality of the design, the time required by the vendor to submit assembly drawings, which show dimensions, orientations, and weights, could vary from weeks to months. Two to six weeks is allowed for this activity on the basis of consultation with suppliers of control equipment.
K-L	One to two weeks is sufficient for review and approval of assembly drawings. The longer time is required for any delay in approval as a result of revisions and modifications.
L-M	Three to eight weeks is normally required for the vendor to prepare the shop or fabrication drawings for fabrication and assembly of the control device. These figures are based on information supplied by vendors of pollution control equipment.

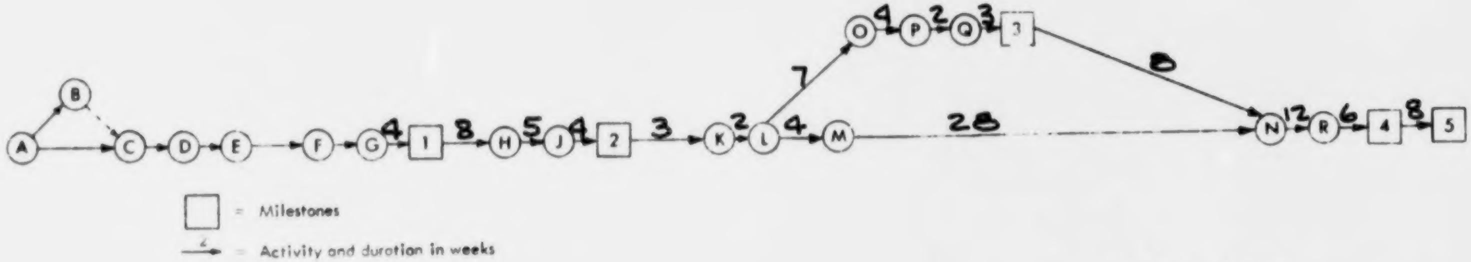
Table 2.2 (Continued)

ACTIVITY	COMMENTS
M-N	On small control devices that can be shop-assembled, this activity represents the fabrication, assembly of components, and delivery of the control unit to the site. On large field-erected control devices, time shown for this activity indicates the fabrication and delivery of the first components (structural) to the site. Delivery of remaining components continues throughout the construction phase. Duration given for this activity is based on consultation with manufacturers of control devices.
L-O	In this activity the client (or his consultant) prepares an engineering drawings package for use by the construction company for pouring foundations, installing structures, ductwork, electrical equipment, and any other items not supplied with the control device. These drawings also show the location and tie-in of the control device. Estimated engineering times for each major type of control device are shown in Table 2.3.
O-P	Engineering drawings and specifications constitute the bulk of the construction bid document. A minimum of four weeks is allocated for obtaining bids from the contractors.
P-Q	Construction bids are evaluated and the successful bidder selected. Two weeks is allowed for this activity.
Q-3	Construction contract is prepared. In large corporations, it is reviewed and approved by several departments before submission to the contractor.
3-N	This activity primarily consists of site clearance, pouring of the foundation, erecting structural members, installing ductwork, and installing auxiliary equipment.

Table 2.2 (Continued)

ACTIVITY	COMMENTS
N-R	For this activity, essentially an extension of the construction work, the time is allocated primarily for installation of a shop-assembled (or modular) control device. For a field-erected unit, it represents the time required to complete the installation of components as they arrive on site. These installation times are based on data supplied by vendors and substantiated by users.
R-4	Two to six weeks is allocated for tie-in. In large installations, where the process cannot be conveniently shut down at the end of the construction phase, longer times may be required.
4-5	Startup, shakedown, and preliminary emissions testing would require from two weeks for a small and simple installation to about eight weeks for a large and complicated system.

Figure 2.2 Schedule for installation of small electrostatic precipitator capacity under 300,000 CFM.



MILESTONES

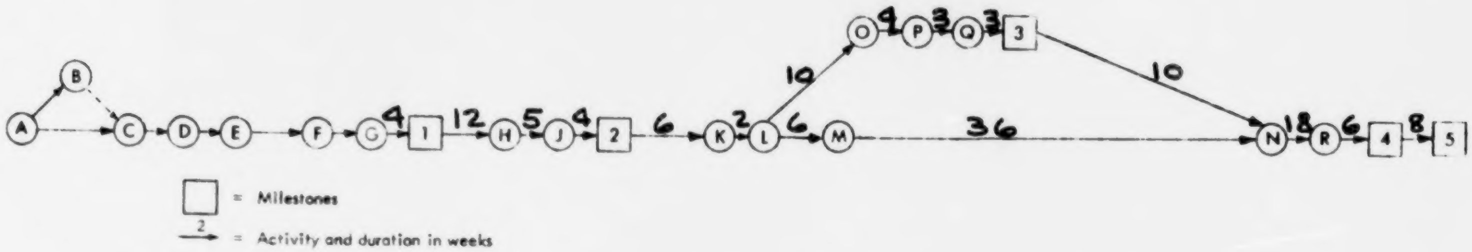
		ELAPSED TIME (WEEKS)
1	Date of submittal of final control plan to appropriate agency	4
2	Date of award of control device contract.	21
3	Date of initiation of on-site construction or installation of emission control equipment	42
4	Date by which on-site construction or installation of emission control equipment is completed	76
5	Date by which final compliance is achieved.	84

ACTIVITIES

Designation	
A-C	Preliminary investigation
A-B	Source tests
C-D	Evaluate control alternatives
D-E	Commit funds for total program
E-F	Prepare preliminary control plan and compliance schedule for agency
F-G	Agency review and approval
G-1	Finalize plans and specifications
1-H	Procure control device bids
H-J	Evaluate control device bids
J-2	Award control device contract
2-K	Vendor prepares assembly drawings

Designation	
K-L	Review and approval of assembly drawings
L-M	Vendor prepares fabrication drawings
M-N	Fabricate control device
L-O	Prepare engineering drawings
O-P	Procure construction bids
P-Q	Evaluate construction bids
Q-3	Award construction contract
3-N	On-site construction
N-R	Install control device
R-4	Complete construction (system tie-in)
4-5	Startup, shakedown, preliminary source test

Figure 2.3 Schedule for installation of large electrostatic precipitator capacity over 300,000 CFM.



MILESTONES

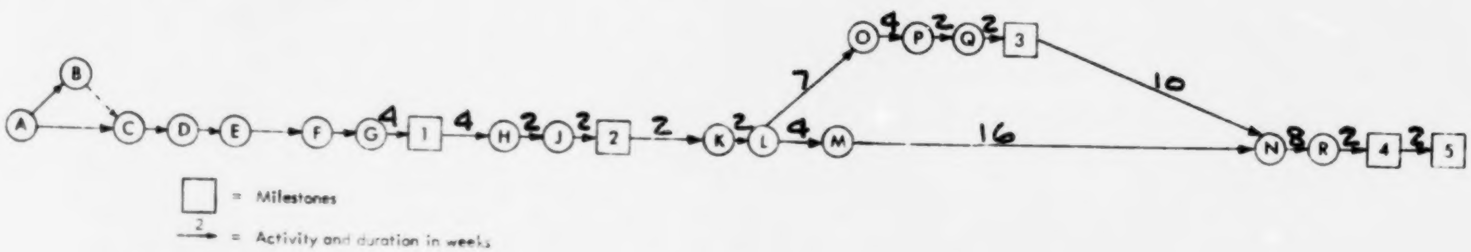
		ELAPSED TIME (WEEKS)
1	Date of submittal of final control plan to appropriate agency.	4
2	Date of award of control device contract.	25
3	Date of initiation of on-site construction or installation of emission control equipment.	63
4	Date by which on-site construction or installation of emission control equipment is completed.	99
5	Date by which final compliance is achieved.	107

ACTIVITIES

Designation	
A-C	Preliminary investigation
A-B	Source tests
C-D	Evaluate control alternatives
D-E	Commit funds for total program
E-F	Prepare preliminary control plan and compliance schedule for agency
F-G	Agency review and approval
G-1	Finalize plans and specifications
1-H	Procure control device bids
H-J	Evaluate control device bids
J-2	Award control device contract
2-K	Vendor prepares assembly drawings

Designation	
K-L	Review and approval of assembly drawings
L-M	Vendor prepares fabrication drawings
M-N	Fabricate control device
L-O	Prepare engineering drawings
O-P	Procure construction bids
P-Q	Evaluate construction bids
Q-3	Award construction contract
3-N	On-site construction
N-R	Install control device
R-4	Complete construction (system tie-in)
4-5	Startup, shakedown, preliminary source test

Figure 2.4 Schedule for installation of small fabric filter under 200,000 ACFM.



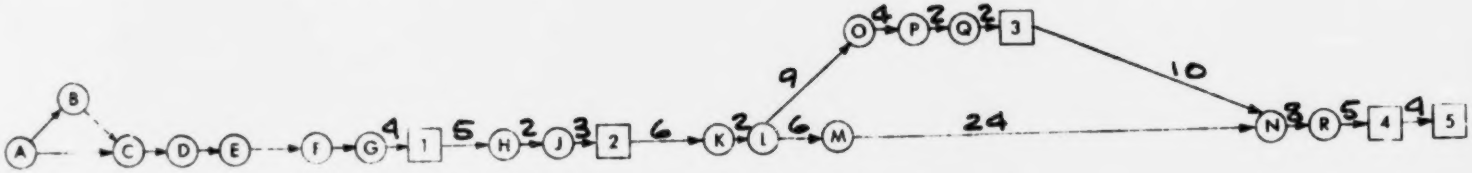
MILESTONES

		ELAPSED TIME (WEEKS)
1	Date of submittal of final control plan to appropriate agency.	4
2	Date of award of control device contract.	12
3	Date of initiation of on-site construction or installation of emission control equipment.	31
4	Date by which on-site construction or installation of emission control equipment is completed.	51
5	Date by which final compliance is achieved.	53

ACTIVITIES

Designation		Designation	
A-C	Preliminary investigation	K-L	Review and approval of assembly drawings
A-B	Source tests	L-M	Vendor prepares fabrication drawings
C-D	Evaluate control alternatives	M-N	Fabricate control device
D-E	Commit funds for total program	L-O	Prepare engineering drawings
E-F	Prepare preliminary control plan and compliance schedule for agency	O-P	Procure construction bids
F-G	Agency review and approval	P-Q	Evaluate construction bids
G-1	Finalize plans and specifications	Q-3	Award construction contract
1-H	Procure control device bids	3-N	On-site construction
H-J	Evaluate control device bids	N-R	Install control device
J-2	Award control device contract	R-4	Complete construction (system tie-in)
2-K	Vendor prepares assembly drawings	4-5	Startup, shakedown, preliminary source test

Figure 2.5 Schedule for installation of large fabric filter capacity over 200,000 CFM.



□ = Milestones

$\xrightarrow{2}$ = Activity and duration in weeks

MILESTONES

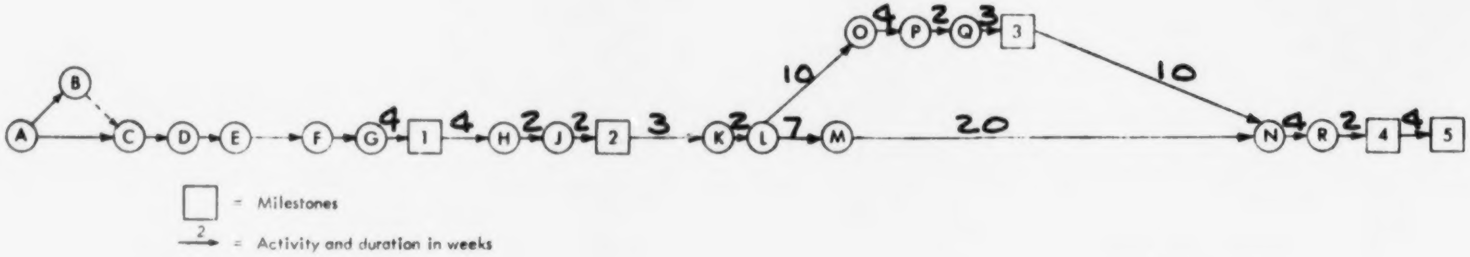
		ELAPSED TIME (WEEKS)
1	Date of submittal of final control plan to appropriate agency.	4
2	Date of award of control device contract.	14
3	Date of initiation of on-site construction or installation of emission control equipment.	39
4	Date by which on-site construction or installation of emission control equipment is completed.	65
5	Date by which final compliance is achieved.	69

ACTIVITIES

Designation	
A-C	Preliminary investigation
A-B	Source tests
C-D	Evaluate control alternatives
D-E	Commit funds for total program
E-F	Prepare preliminary control plan and compliance schedule for agency
F-G	Agency review and approval
G-1	Finalize plans and specifications
1-H	Procure control device bids
H-J	Evaluate control device bids
J-2	Award control device contract
2-K	Vendor prepares assembly drawings

Designation	
K-L	Review and approval of assembly drawings
L-M	Vendor prepares fabrication drawings
M-N	Fabricate control device
L-O	Prepare engineering drawings
O-P	Procure construction bids
P-Q	Evaluate construction bids
Q-3	Award construction contract
3-N	On-site construction
N-R	Install control device
R-4	Complete construction (system tie-in)
4-5	Startup, shakedown, preliminary source test

Figure 2.6 Schedule for installation of low energy wet scrubber capacity under 150,000 CFM.



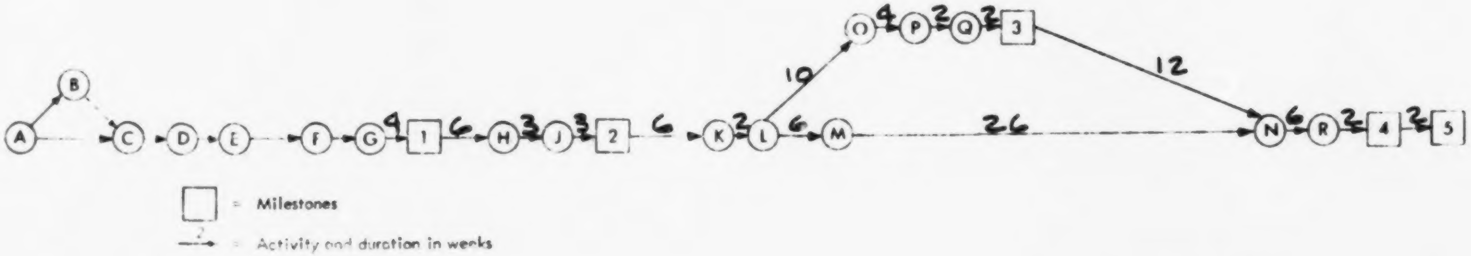
MILESTONES

		ELAPSED TIME (WEEKS)
1	Date of submittal of final control plan to appropriate agency.	4
2	Date of award of control device contract.	12
3	Date of initiation of on-site construction or installation of emission control equipment.	36
4	Date by which on-site construction or installation of emission control equipment is completed.	52
5	Date by which final compliance is achieved.	56

ACTIVITIES

Designation		Designation	
A-C	Preliminary investigation	K-L	Review and approval of assembly drawings
A-B	Source tests	L-M	Vendor prepares fabrication drawings
C-D	Evaluate control alternatives	M-N	Fabricate control device
D-E	Commit funds for total program	L-O	Prepare engineering drawings
E-F	Prepare preliminary control plan and compliance schedule for agency	O-P	Procure construction bids
F-G	Agency review and approval	P-Q	Evaluate construction bids
G-1	Finalize plans and specifications	Q-3	Award construction contract
1-H	Procure control device bids	3-N	On-site construction
H-J	Evaluate control device bids	N-R	Install control device
J-2	Award control device contract	R-4	Complete construction (system tie-in)
2-K	Vendor prepares assembly drawings	4-5	Startup, shakedown, preliminary source test

Figure 2.7 Schedule for installation of high energy wet scrubber capacity under 150,000 CFM.



MILESTONES

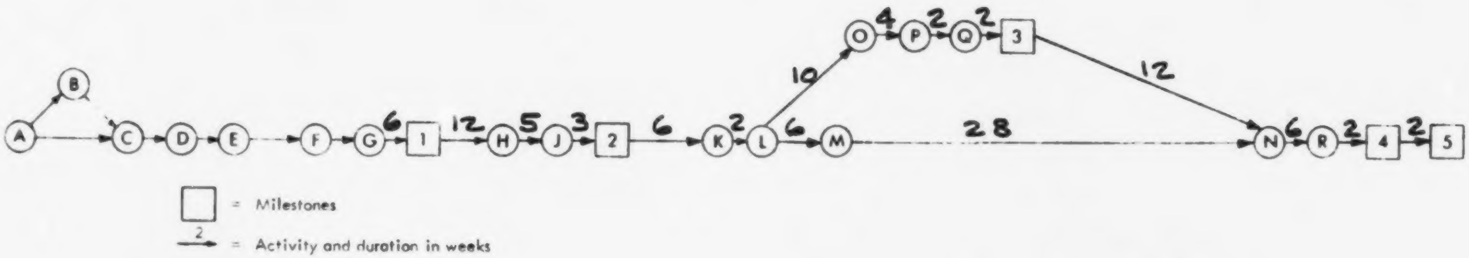
		ELAPSED TIME (WEEKS)
1	Date of submittal of final control plan to appropriate agency.	9
2	Date of award of control device contract.	16
3	Date of initiation of on-site construction or installation of emission control equipment	42
4	Date by which on-site construction or installation of emission control equipment is completed.	64
5	Date by which final compliance is achieved.	66

ACTIVITIES

Designation	
A-C	Preliminary investigation
A-B	Source tests
C-D	Evaluate control alternatives
D-E	Commit funds for total program
E-F	Prepare preliminary control plan and compliance schedule for agency
F-G	Agency review and approval
G-1	Finalize plans and specifications
1-H	Procure control device bids
H-J	Evaluate control device bids
J-2	Award control device contract
2-K	Vendor prepares assembly drawings

Designation	
K-L	Review and approval of assembly drawings
L-M	Vendor prepares fabrication drawings
M-N	Fabricate control device
L-O	Prepare engineering drawings
O-P	Procure construction bids
P-Q	Evaluate construction bids
Q-3	Award construction contract
3-N	On-site construction
N-R	Install control device
R-4	Complete construction (system tie-in)
4-5	Startup, shakedown, preliminary source test

Figure 2.8 Schedule for installation of a high energy wet scrubber system capacity over 150,000 CFM.



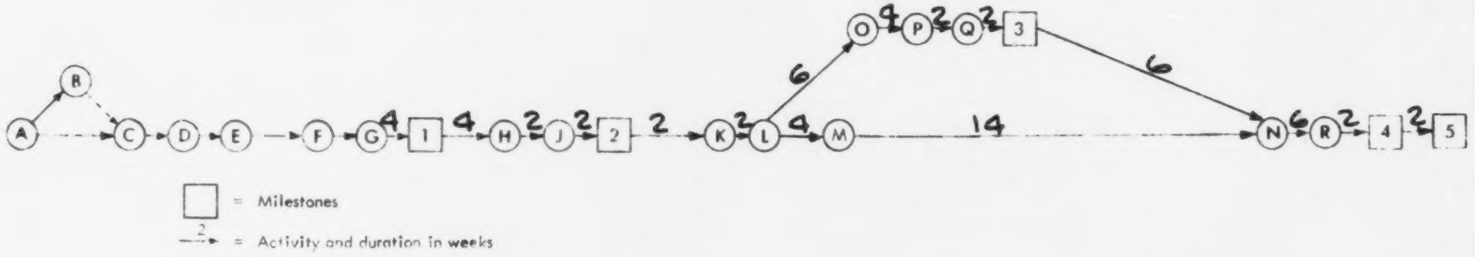
MILESTONES		ELAPSED TIME (WEEKS)
1	Date of submittal of final control plan to appropriate agency.	6
2	Date of award of control device contract.	26
3	Date of initiation of on-site construction or installation of emission control equipment.	52
4	Date by which on-site construction or installation of emission control equipment is completed.	74
5	Date by which final compliance is achieved.	76

ACTIVITIES

Designation	
A-C	Preliminary investigation
A-B	Source tests
C-D	Evaluate control alternatives
D-E	Commit funds for total program
E-F	Prepare preliminary control plan and compliance schedule for agency
F-G	Agency review and approval
G-1	Finalize plans and specifications
1-H	Procure control device bids
H-J	Evaluate control device bids
J-2	Award control device contract
2-K	Vendor prepares assembly drawings

Designation	
K-L	Review and approval of assembly drawings
L-M	Vendor prepares fabrication drawings
M-N	Fabricate control device
L-O	Prepare engineering drawings
O-P	Procure construction bids
P-Q	Evaluate construction bids
Q-3	Award construction contract
3-N	On-site construction
N-R	Install control device
R-4	Complete construction (system tie-in)
4-5	Startup, shakedown, preliminary source test

Figure 2.9 Schedule for installation of an afterburner.



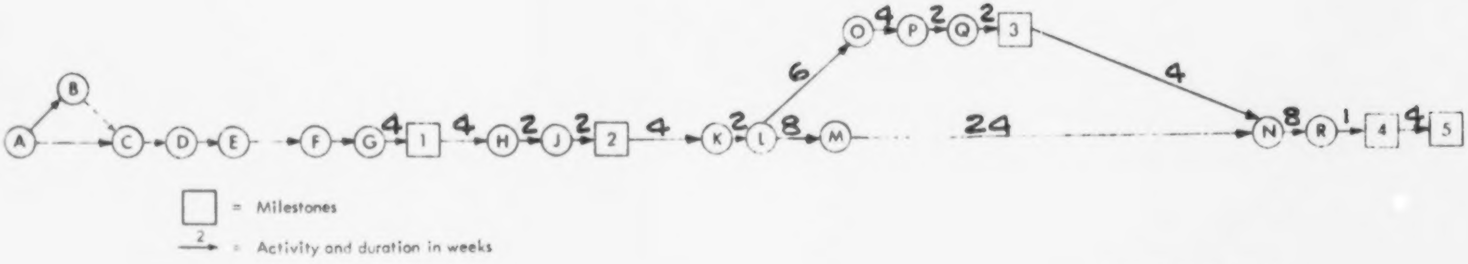
MILESTONES		ELAPSED TIME (WEEKS)
1	Date of submittal of final control plan to appropriate agency.	4
2	Date of award of control device contract.	12
3	Date of initiation of on-site construction or installation of emission control equipment.	30
4	Date by which on-site construction or installation of emission control equipment is completed.	44
5	Date by which final compliance is achieved.	46

ACTIVITIES

Designation	
A-C	Preliminary investigation
A-B	Source tests
C-D	Evaluate control alternatives
D-E	Commit funds for total program
E-F	Prepare preliminary control plan and compliance schedule for agency
F-G	Agency review and approval
G-1	Finalize plans and specifications
1-H	Procure control device bids
H-J	Evaluate control device bids
J-2	Award control device contract
2-K	Vendor prepares assembly drawings

Designation	
K-L	Review and approval of assembly drawings
L-M	Vendor prepares fabrication drawings
M-N	Fabricate control device
L-O	Prepare engineering drawings
O-P	Procure construction bids
P-Q	Evaluate construction bids
Q-3	Award construction contract
3-N	On-site construction
N-R	Install control device
R-4	Complete construction (system tie-in)
4-5	Startup, shakedown, preliminary source test

Figure 2.10 Schedule for installation of packaged adsorption system, including field-erected distillation unit.



MILESTONES

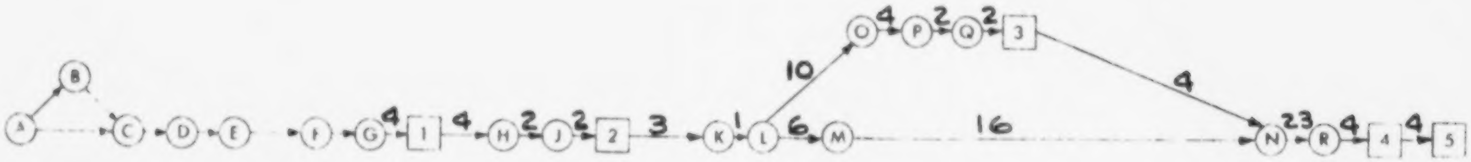
		ELAPSED TIME (WEEKS)
1	Date of submittal of final control plan to appropriate agency	4
2	Date of award of control device contract.	12
3	Date of initiation of on-site construction or installation of emission control equipment	32
4	Date by which on-site construction or installation of emission control equipment is completed.	59
5	Date by which final compliance is achieved	63

ACTIVITIES

Designation	
A-C	Preliminary investigation
A-B	Source tests
C-D	Evaluate control alternatives
D-E	Commit funds for total program
E-F	Prepare preliminary control plan and compliance schedule for agency
F-G	Agency review and approval
G-I	Finalize plans and specifications
I-H	Procure control device bids
H-J	Evaluate control device bids
J-2	Award control device contract
2-K	Vendor prepares assembly drawings

Designation	
K-L	Review and approval of assembly drawings
L-M	Vendor prepares fabrication drawings
M-N	Fabricate control device
L-O	Prepare engineering drawings
O-P	Procure construction bids
P-Q	Evaluate construction bids
Q-3	Award construction contract
3-N	On-site construction
N-R	Install control device
R-4	Complete construction (system tie-in)
4-5	Startup, shakedown, preliminary source test

Figure 2.11 Schedule for installation of field-erected adsorption system, including distillation unit.



☐ = Milestones

$\xrightarrow{2}$ = Activity and duration in weeks

MILESTONES

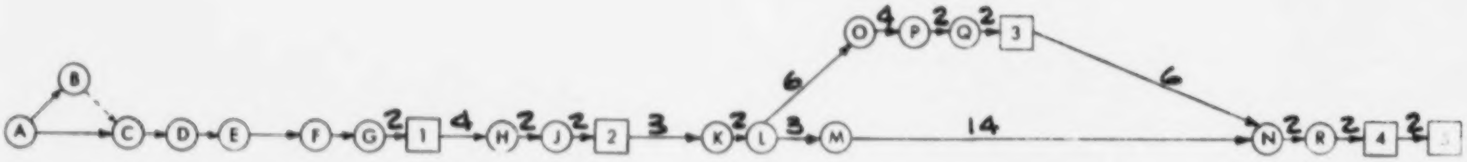
		ELAPSED TIME (WEEKS)
1	Date of submittal of final control plan to appropriate agency.	9
2	Date of award of control device contract.	12
3	Date of initiation of on-site construction or installation of emission control equipment.	34
4	Date by which on-site construction or installation of emission control equipment is completed.	65
5	Date by which final compliance is achieved.	69

ACTIVITIES

Designation	
A-C	Preliminary investigation
A-B	Source tests
C-D	Evaluate control alternatives
D-E	Commit funds for total program
E-F	Prepare preliminary control plan and compliance schedule for agency
F-G	Agency review and approval
G-1	Finalize plans and specifications
1-H	Procure control device bids
H-J	Evaluate control device bids
J-2	Award control device contract
2-K	Vendor prepares assembly drawings

Designation	
K-L	Review and approval of assembly drawings
L-M	Vendor prepares fabrication drawings
M-N	Fabricate control device
L-O	Prepare engineering drawings
O-P	Procure construction bids
P-Q	Evaluate construction bids
Q-3	Award construction contract
3-N	On-site construction
N-R	Install control device
R-4	Complete construction (system tie-in)
4-5	Startup, shakedown, preliminary source test

Figure 2.12 Schedule for installation of high energy air filter (HEAF) unit.



□ = Milestones

$\xrightarrow{2}$ = Activity and duration in weeks

MILESTONES		ELAPSED TIME (WEEKS)
1	Date of submittal of final control plan to appropriate agency.	2
2	Date of award of control device contract.	10
3	Date of initiation of on-site construction or installation of emission control equipment.	29
4	Date by which on-site construction or installation of emission control equipment is completed.	39
5	Date by which final compliance is achieved.	91

ACTIVITIES

Designation		Designation	
A-C	Preliminary investigation	K-L	Review and approval of assembly drawings
A-B	Source tests	L-M	Vendor prepares fabrication drawings
C-D	Evaluate control alternatives	M-N	Fabricate control device
D-E	Commit funds for total program	L-O	Prepare engineering drawings
E-F	Prepare preliminary control plan and compliance schedule for agency	O-P	Procure construction bids
F-G	Agency review and approval	P-Q	Evaluate construction bids
G-1	Finalize plans and specifications	Q-3	Award construction contract
1-H	Procure control device bids	3-N	On-site construction
H-J	Evaluate control device bids	N-R	Install control device
J-2	Award control device contract	R-4	Complete construction (system tie-in)
2-K	Vendor prepares assembly drawings	4-5	Startup, shakedown, preliminary source test

Table 2.3 ESTIMATED SCHEDULE OF ENGINEERING DRAWINGS
ACTIVITY DESIGNATION (L-O)

CONTROL DEVICE	SIZE	PROJECT DESIGN (1)	LAYOUT DRAWINGS (2)	STRUCTURAL DRAWINGS (3)	FOUNDATION DRAWINGS (4)	MECHANICAL DRAWINGS (5)	ELECTRICAL DRAWINGS (6)	CHECK CONST. PACKAGE (7)	ELAPSED TIME[a] (8)
Electrostatic Precipitator	Small	40 hrs	2	1	1	3	1	40 hrs	7 weeks
Electrostatic Precipitator	Large	80 hrs	2	1	1	3	1	80 hrs	10 weeks
Fabric Filters	Small	40 hrs	2	1	1	3	1	40 hrs	7 weeks
Fabric Filters	Large	80 hrs	2	1	1	3	1	80 hrs	9 weeks
High Energy Wet Scrubber	Small	40 hrs	2	2	1	6	1	40 hrs	10 weeks
High Energy Wet Scrubber	Large	40 hrs	2	2	1	6	1	40 hrs	10 weeks
Solvent Recovery Unit	Shop Assembled	40 hrs	1	2	1	3	1	40 hrs	6 weeks
Solvent Recovery Unit	Field Erected	40 hrs	2	2	1	6	1	40 hrs	10 weeks
Afterburner	Thermal/ Catalytic	40 hrs	2	1	2	1	1	40 hrs	6 weeks
High Energy Air Filter		40 hrs	2	1	2	1	1	40 hrs	6 weeks

(a) Elapsed time is computed by multiplying the total of drawings in Columns (2) and (5) by 40 hours and adding to the total figures shown in Columns (1) and (7), then dividing by 40 hours to obtain the time in weeks.

pressure to install the devices in a prompt manner. Many case histories also included several specification change-orders by the customer, which delayed fabrication and delivery of the control device.

It is emphasized that these composite schedules are based on somewhat arbitrary break points in capacities (ACFM); within each size range, significant variations in elapsed time can occur. A number of factors influencing the delivery and construction phases of these schedules may have more effect on the final schedule than the size of the control device: (a) special designs, which may require new fabrication drawings and different fabrication procedures; (b) special materials of construction; (c) limited space, necessitating unusual control system configuration or moving of process equipment; (d) extensive modifications of the process to accommodate the emission control system; (e) type of contract -- erected, non-erected, turn-key; and (f) type of unit -- shop-fabricated, modular, or field-erected.

Although these schedules are necessarily more general and less precise than those presented in Section 3.0, they should provide reasonable guidelines for evaluating or developing compliance schedules for those sources not described in Section 3.0.

2.3 Contingencies Affecting Compliance Schedules

The elapsed time of these compliance schedules represents the "expeditiously as practicable" time needed to install control equipment to achieve compliance with air pollution regulations. Although the phrase "expeditiously as practicable" defies precise definition, it generally refers to the minimum time during which it is possible for operators of a facility to attain compliance, considering lead times for engineering design, contracting, construction, installation and startup, and considering special problems in locating or operating control equipment. Economic factors are considered of secondary importance. It was assumed that the design and construction work is performed during normal working hours; thus the schedules may be shortened by overtime work. The elapsed times shown on the schedules may increase as a result of a variety of unforeseen problems that may occur in the activity steps shown in Figure 2.1. Potential problems, by activity, include the following:

Preparation of Engineering Drawings (L-O): Backlogs of engineering work at the firm's engineering department or consulting firm may delay assignment of engineers and draftsmen to the project. This may not cause a delay in the overall schedule as long as activities along L-3-N are of lesser duration than those along L-M-N.

Fabrication of Control Device (M-N): Delays in fabrication could result from backlog of orders at the shop, union strike, shortage of special material, change in specifications by the customer, and delay in customer approval of vendor's drawings.

On large installations, where delivery times for air pollution control devices are usually long, any delay in this activity will directly affect the overall schedule.

On-Site Construction (3-N): This activity is susceptible to delays resulting from lack of skilled labor at the needed times, union strikes, vandalism, theft, severe weather, and shortage of material.

Install Control Device (N-R): Installation of the control device is essentially an extension of the construction activity and is subject to the same contingencies. On retrofit jobs where lay-down space is limited, the arrival of material on site might have to be phased and construction would proceed at a slower pace.

Complete Construction and System Tie-In (R-4): The longest delay in this activity could result from the inability to shut down the process to make the needed tie-ins, because shut down would cause severe economic or other losses. On large or critical operations, tie-in time could be minimized by installing blinded tie-in points during the early part of the construction phase.

Startup, Shakedown, Preliminary Emissions Testing (4-5): Delays in startup could be due to shortage of replacement parts, equipment malfunction, improper equipment design, or lack of available control manufacturer personnel to shakedown the unit. On new processes, startup and emissions testing could be delayed indefinitely while awaiting the construction, startup, and debugging of new process or boiler equipment.

3.0 COMPLIANCE SCHEDULES FOR SELECTED INDUSTRIAL SOURCES

3.1 Stationary Combustion

3.1.1 Coal-Fired Utility Boilers

Process Description - Individual coal-fired utility boilers range in size from small units generating about 20 MW of power to units generating over 1000 MW. The smaller units are usually operated for peak loading (i.e. to generate the additional power needed during peak power usage hours) whereas the larger boilers are usually operated continuously to provide the base load. At large power generating stations with several boilers, generating capacities can reach several thousand megawatts.

The overall process for power generation at a coal-fired utility is shown schematically in Figure 3.1.1. Coal is usually received by barge or rail, sized, and then fired into the furnace; the heat from combustion is used to produce steam for generating power. Most coal-fired utilities use either pulverized coal or cyclone-fired boilers, the pulverized-coal-fired units vastly predominating. Almost all units in current use are equipped with some type of device for fly ash control.

Atmospheric Emissions - Sources of particulate emission include the coal receiving and handling operations, the furnace flue

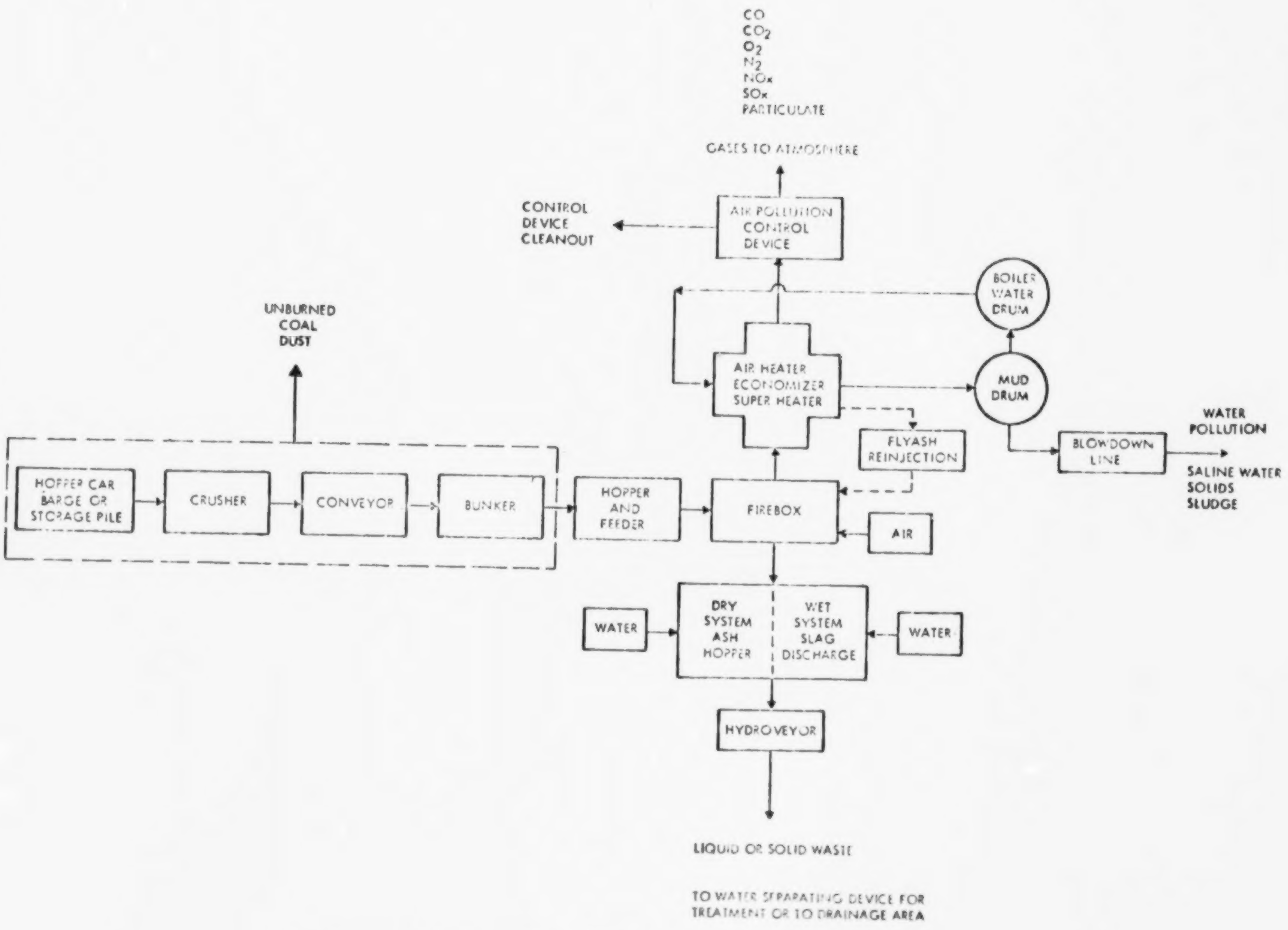

CO
CO_2
O_2
N_2
NO_x
SO_x
PARTICULATE
GASES TO ATMOSPHERE
CONTROL DEVICE CLEANOUT
AIR POLLUTION CONTROL DEVICE
BOILER WATER DRUM
UNBURNED COAL DUST
AIR HEATER ECONOMIZER SUPER HEATER
MUD DRUM
WATER POLLUTION
FLYASH REINJECTION
BLOWDOWN LINE
SALINE WATER
SOLIDS
SLUDGE
HOPPER CAR BARGE OR STORAGE PILE
CRUSHER
CONVEYOR
BUNKER
HOPPER AND FEEDER
FIREBOX
AIR
WATER
DRY SYSTEM ASH HOPPER
WET SYSTEM SLAG DISCHARGE
WATER
HYDROVEYOR
LIQUID OR SOLID WASTE
TO WATER SEPARATING DEVICE FOR TREATMENT OR TO DRAINAGE AREA

Figure 3.1.1 Coal-fired power utility.

gases, and the ash disposal operations. Of these, the fly ash contained in the flue gases represents the largest particulate emission sources. The flue gases also can contain substantial amounts of sulfur oxides and nitrogen oxides.

Pulverized-coal-fired boilers generally emit, as fly ash, between 75 and 85 percent of the ash content of the coal. For example, a unit burning coal having 10% ash content emits approximately 160 pounds of fly ash per ton of coal burned. Cyclone-fired units emit considerably less, approximately 10% of the total ash content of the coal; a unit burning coal having 10% ash content emits approximately 20 pounds fly ash per ton of coal burned.

Control Systems - Electrostatic precipitators have been used almost exclusively for high-efficiency particulate control. These devices are capable of operating with collection efficiencies of more than 99 percent. In design of the precipitator, particular attention must be paid to the sulfur content of the coal and expected precipitator operating temperature; both parameters influence fly ash resistivity, which in turn directly affects collection efficiency.

Within the last few years, wet scrubbers have also been installed to control particulate emissions from coal-fired boilers. Usually such installations are made in anticipation of converting the scrubber system to collect both SO_2 and particulate, not just particulate emissions.

Conversion from coal to oil or gas also effectively reduces particulate and SO_2 emissions.

Compliance Schedules - Figures 3.1.2 and 3.1.3 illustrate expeditious schedules for installation of an electrostatic precipitator and a wet scrubber for particulate control. No schedule is shown for SO_2 and NO_x control since these systems should be studied on an individual basis.

The elapsed time of these schedules may increase as a result of delays in control device fabrication, staggering the installation of several devices at one site, and a multitude of startup problems. Because of their backlogs of orders, some of the leading precipitator manufacturers can exceed the quoted delivery schedules by as much as 16 weeks. Approximately 12 to 24 weeks is usually required for installation of each additional precipitator after the first unit has been completed because utilities must stagger the down times of the various boilers to meet power generation requirements. Although this additional time can be shortened, the schedules must be considered on an individual basis for each utility. The variety of startup problems encountered with large precipitators can require more than 6 months to rectify before achieving satisfactory operation and thus compliance unless an intensive effort is made by both the utility and precipitator manufacturers.

Sources of Additional Information

Source	Type of Information*
1. Handbook of Emissions, Effluents, and Control Practices for Stationary Particulate Pollution Sources NTIS No: PB 203-522	P, E, C
2. A Manual of Electrostatic Precipitator Technology, Part II - Application Areas NTIS No. PB 196-381	C
3. Steam, Its Generation and Use Babcock and Wilcox Company, 1963	P
4. Atmospheric Emissions from Coal Combustion PHS Publication No. 999-AP-24	P, E

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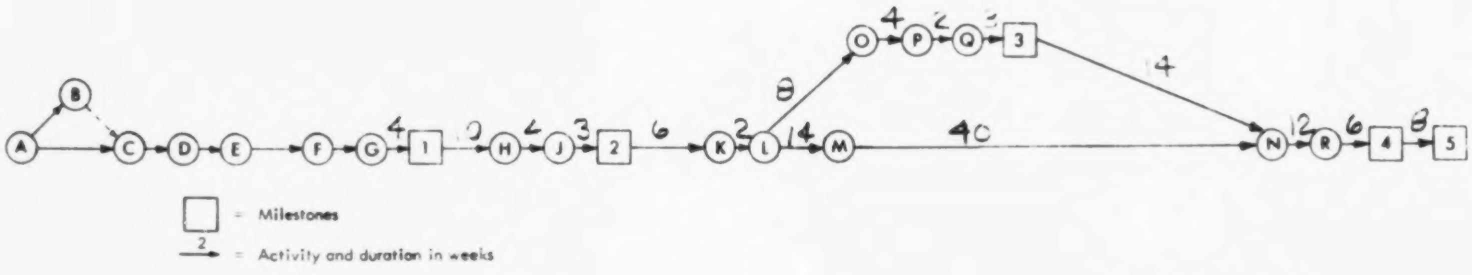
* P = Process description
E = Emission rates
C = Control devices

Figure 3.1.2 Schedule for installation of an electrostatic precipitator for particulate pollutant control.



MILESTONES

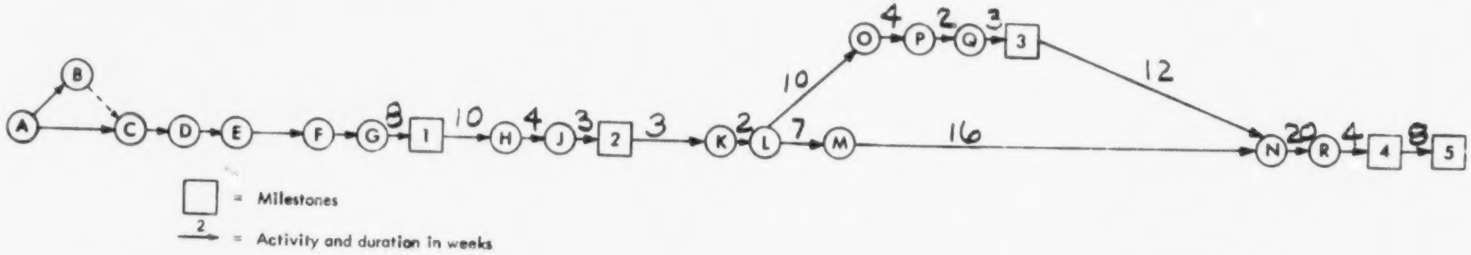
		ELAPSED TIME (WEEKS)
1	Date of submittal of final control plan to appropriate agency.	4
2	Date of award of control device contract.	21
3	Date of initiation of on-site construction or installation of emission control equipment.	46
4	Date by which on-site construction or installation of emission control equipment is completed.	101
5	Date by which final compliance is achieved.	109

ACTIVITIES

Designation	
A-C	Preliminary investigation
A-B	Source tests
C-D	Evaluate control alternatives
D-E	Commit funds for total program
E-F	Prepare preliminary control plan and compliance schedule for agency
F-G	Agency review and approval
G-1	Finalize plans and specifications
1-H	Procure control device bids
H-J	Evaluate control device bids
J-2	Award control device contract
2-K	Vendor prepares assembly drawings

Designation	
K-L	Review and approval of assembly drawings
L-M	Vendor prepares fabrication drawings
M-N	Fabricate control device
L-O	Prepare engineering drawings
O-P	Procure construction bids
P-Q	Evaluate construction bids
Q-3	Award construction contract
3-N	On-site construction
N-R	Install control device
R-4	Complete construction (system tie-in)
4-5	Startup, shakedown, preliminary source test

Figure 3.1.3 Schedule for installation of a wet scrubber for particulate pollutant control on a coal-fired utility boiler.



MILESTONES

		ELAPSED TIME (WEEKS)
1	Date of submittal of final control plan to appropriate agency.	8
2	Date of award of control device contract.	25
3	Date of initiation of on-site construction or installation of emission control equipment.	49
4	Date by which on-site construction or installation of emission control equipment is completed.	85
5	Date by which final compliance is achieved.	93

ACTIVITIES

Designation		Designation	
A-C	Preliminary investigation	K-L	Review and approval of assembly drawings
A-B	Source tests	L-M	Vendor prepares fabrication drawings
C-D	Evaluate control alternatives	M-N	Fabricate control device
D-E	Commit funds for total program	L-O	Prepare engineering drawings
E-F	Prepare preliminary control plan and compliance schedule for agency	O-P	Procure construction bids
F-G	Agency review and approval	P-Q	Evaluate construction bids
G-1	Finalize plans and specifications	Q-3	Award construction contract
1-H	Procure control device bids	3-N	On-site construction
H-J	Evaluate control device bids	N-R	Install control device
J-2	Award control device contract	R-4	Complete construction (system tie-in)
2-K	Vendor prepares assembly drawings	4-5	Startup, shakedown, preliminary source test

3.1.2 Coal-Fired Industrial Boilers

Process Description - Coal-fired industrial boilers are generally distinguished from large utility boilers by their size, coal-firing method, and operating steam pressure. Capacities of industrial boilers are lower, ranging from 1000 to 500,000 pounds per hour of steam. Pulverized-coal-fired boilers are used for generating steam loads of 300,000 pounds per hour or higher. The smaller boilers are often operated with wide variations in loads, and stoker-fired furnaces are uniquely suited to this fluctuating demand.

Atmospheric Emissions - Sources of particulate emission from industrial boilers are identical to those from utility boilers: the coal receiving and handling operations, the furnace flue gases, and the ash disposal operations. Fly ash in the flue gas represents the major particulate emission source. The quantity emitted depends upon the ash content of the coal, the method of combustion, and the control equipment used. Uncontrolled pulverized-coal-fired boilers generally emit about 160 pounds of fly ash for each ton of coal burned. Emissions from stoker-fired furnaces are about 130 pounds per ton of coal, but vary widely.

Control Systems - Electrostatic precipitators have been used almost exclusively for high-efficiency particulate emission control. Their use on industrial size boilers has not been widespread, however; most installations are equipped only with mechanical collectors, if anything. Electrostatic precipitators can attain efficiencies of more than 99 percent. In precipitator design, particular attention should be given to the sulfur content of the coal to be burned and the expected operating precipitator temperature, since both factors affect collection efficiency.

Some facilities are installing wet scrubbers for fly ash control because of the possibility of modifying the control system at a later date for collection of sulfur oxides.

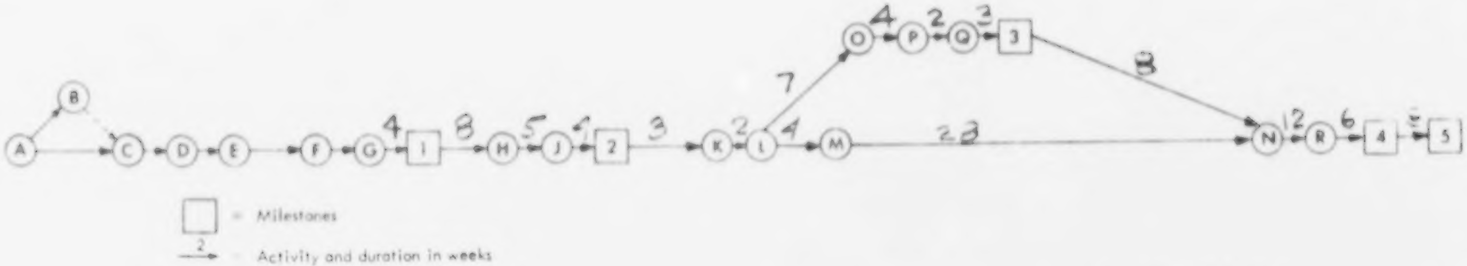
Compliance Schedules - Figures 3.1.4 and 3.1.5 illustrate, respectively, expeditious schedules for installation of an electrostatic precipitator and a wet scrubber for fly ash control. The time required for installation of additional units on the same site after completion of the first unit can add 3 months to the schedule. No schedule is shown for SO_2 and NO_x control, since these systems should be studied on an individual basis.

Sources of Additional Information

Source	Type of Information*
1. A Manual of Electrostatic Precipitator Technology, Part II - Application Areas NTIS No. PB-196-381	C
2. Atmospheric Emissions from Coal Combustion PHS Publication No. 999-AP-24	P, E
3. Steam, Its Generation and Use Babcock and Wilcox Company, 1963	P
4. Background Information for Proposed New-Source Performance Standards: Steam Generators, Incinerators, Portland Cement Plants, Nitric Acid Plants, and Sulfuric Acid Plants NTIS No. PB 202-459	E, C

* P = Process description
E = Emission rates
C = Control devices

Figure 3.1.4 Schedule for installation of an electrostatic precipitator for particulate pollutant control on coal-fired industrial boiler.



☐ = Milestones

2 → = Activity and duration in weeks

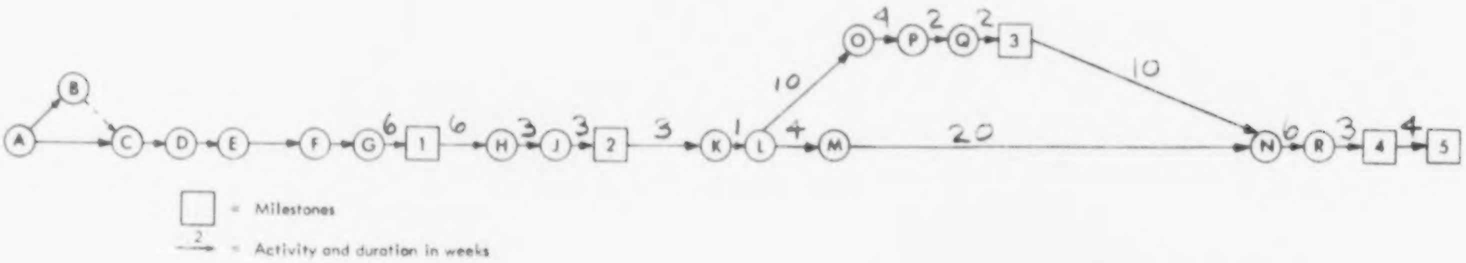
MILESTONES

		ELAPSED TIME (WEEKS)
1	Date of submittal of final control plan to appropriate agency.	4
2	Date of award of control device contract.	21
3	Date of initiation of on-site construction or installation of emission control equipment.	42
4	Date by which on-site construction or installation of emission control equipment is completed.	76
5	Date by which final compliance is achieved.	84

ACTIVITIES

Designation		Designation	
A-C	Preliminary investigation	K-L	Review and approval of assembly drawings
A-B	Source tests	L-M	Vendor prepares fabrication drawings
C-D	Evaluate control alternatives	M-N	Fabricate control device
D-E	Commit funds for total program	L-O	Prepare engineering drawings
E-F	Prepare preliminary control plan and compliance schedule for agency	O-P	Procure construction bids
F-G	Agency review and approval	P-Q	Evaluate construction bids
G-1	Finalize plans and specifications	Q-3	Award construction contract
1-H	Procure control device bids	3-N	On-site construction
H-J	Evaluate control device bids	N-R	Install control device
J-2	Award control device contract	R-4	Complete construction (system tie-in)
2-K	Vendor prepares assembly drawings	4-5	Startup, shakedown, preliminary source test

Figure 3.1.5 Schedule for installation of a wet scrubber for particulate pollutant control on a coal-fired industrial boiler.



MILESTONES

		ELAPSED TIME (WEEKS)
1	Date of submittal of final control plan to appropriate agency.	6
2	Date of award of control device contract.	18
3	Date of initiation of on-site construction or installation of emission control equipment.	40
4	Date by which on-site construction or installation of emission control equipment is completed.	59
5	Date by which final compliance is achieved.	63

ACTIVITIES

Designation	
A-C	Preliminary investigation
A-B	Source tests
C-D	Evaluate control alternatives
D-E	Commit funds for total program
E-F	Prepare preliminary control plan and compliance schedule for agency
F-G	Agency review and approval
G-1	Finalize plans and specifications
1-H	Procure control device bids
H-J	Evaluate control device bids
J-2	Award control device contract
2-K	Vendor prepares assembly drawings

Designation	
K-L	Review and approval of assembly drawings
L-M	Vendor prepares fabrication drawings
M-N	Fabricate control device
L-O	Prepare engineering drawings
O-P	Procure construction bids
P-Q	Evaluate construction bids
Q-3	Award construction contract
3-N	On-site construction
N-R	Install control device
R-4	Complete construction (system tie-in)
4-5	Startup, shakedown, preliminary source test

3.2 Solid Waste Disposal

3.2.1 Municipal Incinerators

Process Description - Capacities of municipal incinerators range from approximately 50 to 1000 tons of refuse per day. In the incineration process, as shown in Figure 3.2.1, refuse is brought to the unloading/charging area. It is then fed to the incinerator, either in batches or continuously, and the combustible fraction of the refuse is burned. In multiple chamber units, air may be added in mixing or secondary chambers to complete the combustion of the volatile materials driven off in the primary refuse burning chamber.

The ash residue from the furnace is periodically removed, quenched, and disposed of, usually in a landfill.

Atmospheric Emissions - Sources of particulate emissions include combustion gases from the furnace and fugitive dust emissions from the handling and disposing of ash from furnace and control device hoppers. Odors can also be a serious problem if proper housekeeping procedures are not strictly followed. Of these sources, the furnace combustion gases represent the largest emission potential. The particulate emission rate is highly

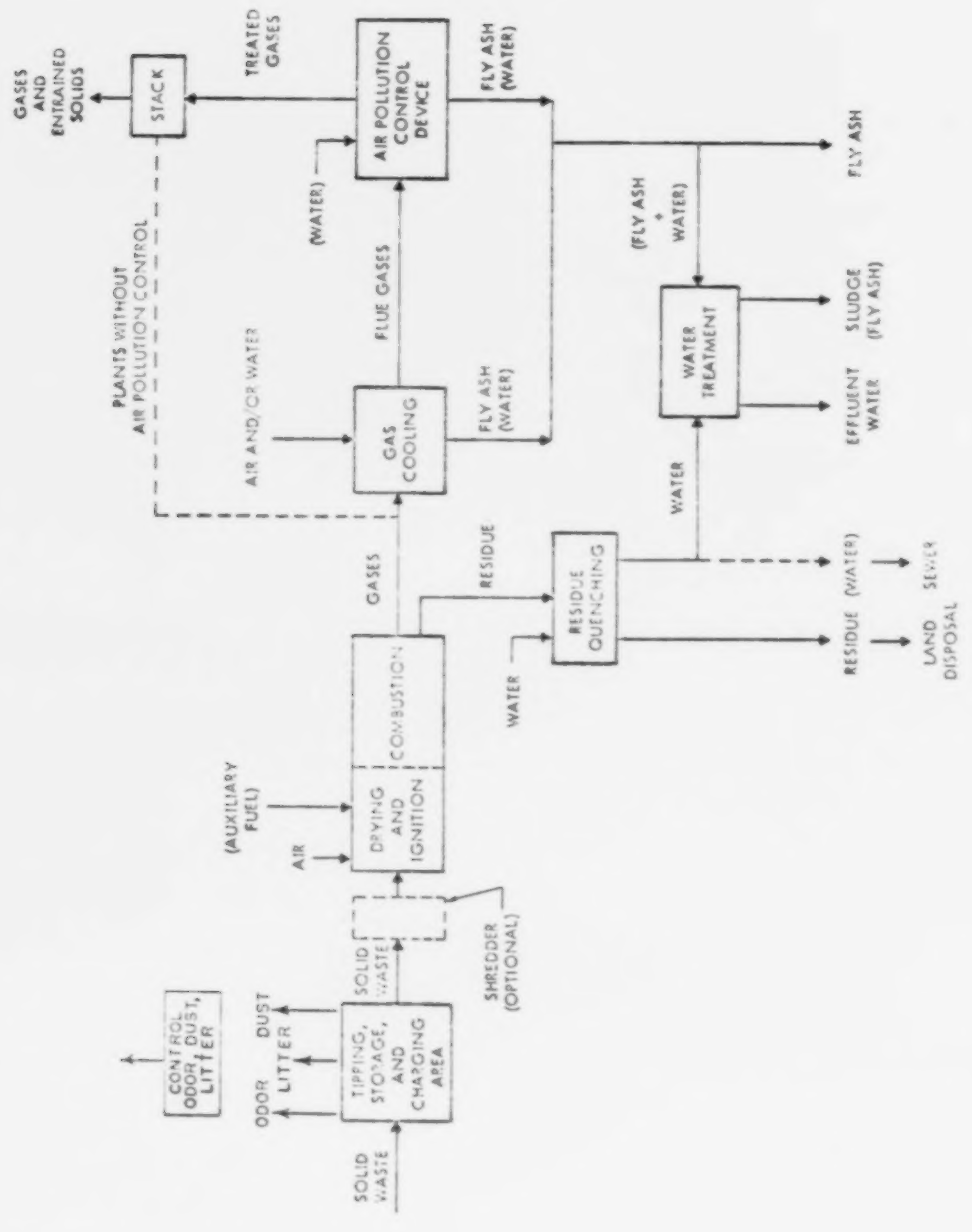

SOLID WASTE
TIPPING, STORAGE, AND CHARGING AREA
ODOR
LITTER
DUST
CONTROL ODOR, DUST, LITTER
SOLID WASTE
SHREDDER (OPTIONAL)
AIR
(AUXILIARY FUEL)
DRYING AND IGNITION
COMBUSTION
GASES
RESIDUE
WATER
RESIDUE QUENCHING
RESIDUE
LAND DISPOSAL
RESIDUE (WATER)
SEWER
WATER
PLANTS WITHOUT AIR POLLUTION CONTROL
AIR AND/OR WATER
GAS COOLING
FLY ASH (WATER)
FLUE GASES
(WATER)
AIR POLLUTION CONTROL DEVICE
TREATED GASES
STACK
GASES AND ENTRAINED SOLIDS
FLY ASH (WATER)
(FLY ASH + WATER)
WATER TREATMENT
EFFLUENT WATER
SLUDGE (FLY ASH)
FLY ASH

Figure 3.2.1 Municipal incinerator process.

variable, depending upon such factors as furnace design, operating conditions, and type and characteristics of the refuse. Particulate emissions from an uncontrolled incinerator typically range between 8 and 70 pounds per ton of refuse burned.

Control Systems - Many incinerators are designed with a settling chamber and water spray or baffle as an integral part of the incinerator system. Although these are considered air pollution control systems, their collection efficiencies are generally very low on a weight basis. They do not provide sufficient control to meet most emission regulations.

Wet scrubbers are the most common high-efficiency air pollution control devices installed on municipal incinerators. Scrubber systems should operate with pressure drops between approximately 10 and 25 inches of water to be effective for meeting most regulations. Electrostatic precipitators are also being installed to control emissions. Both these devices are capable of operating with collection efficiencies as high as 99 percent.

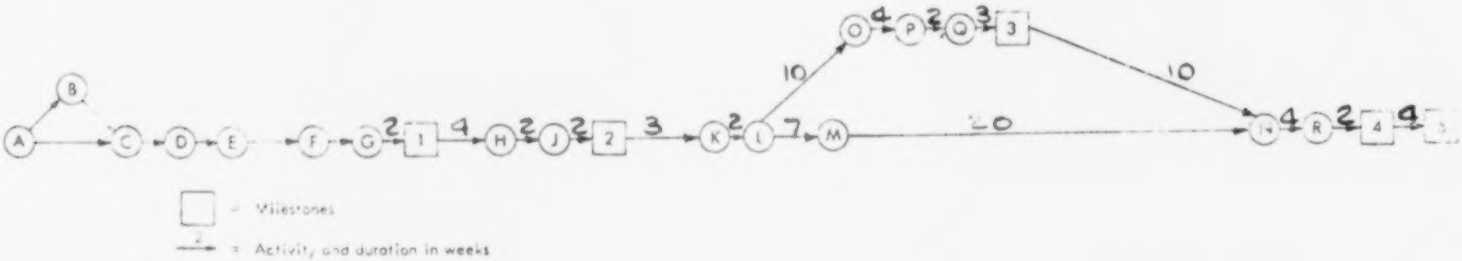
Compliance Schedules - Figures 3.2.2 and 3.2.3, respectively, illustrate expeditious schedules for installation of a wet scrubber and an electrostatic precipitator for incinerator combustion gases. The schedule for the wet scrubber system includes the time required for installation of associated equipment for waste water treatment.

Sources of Additional Information

Source	Type of Information*
1. Systems Study of Air Pollution from Municipal Incinerators APTD-1283, 1284, 1285	P, E, C
2. A Manual of Electrostatic Precipitator Technology, Part II-Application Areas NTIS No. PB 196-381	C
3. Municipal Incineration, A Review of Literature Publication No. AP-079	P, E, C
4. Air Pollution Aspects of Emission Sources: Municipal Incineration Publication No. AP-092	E, C

* P = Process description
E = Emission rates
C = Control devices

Figure 3.2.2 Schedule for installation of a wet scrubber for particulate pollutant control on a municipal incinerator.



MILESTONES

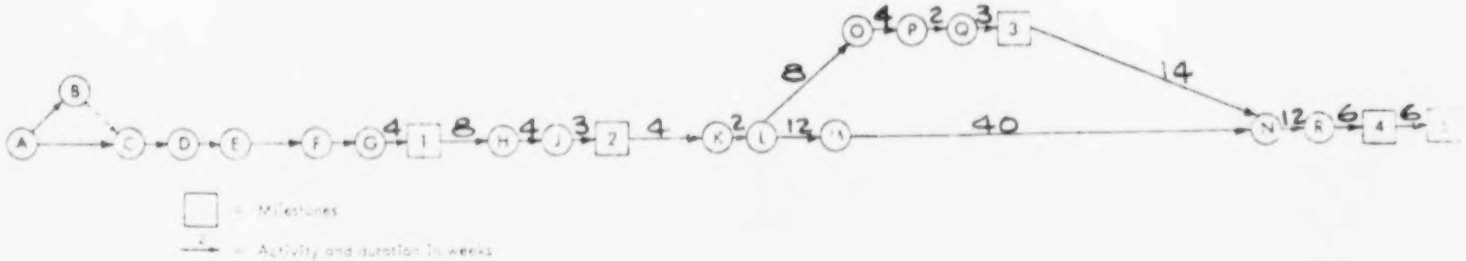
		ELAPSED TIME (WEEKS)
1	Date of submittal of final control plan to appropriate agency.	2
2	Date of award of control device contract.	10
3	Date of initiation of on-site construction or installation of emission control equipment.	34
4	Date by which on-site construction or installation of emission control equipment is completed.	50
5	Date by which final compliance is achieved.	54

ACTIVITIES

Designation	
A-C	Preliminary investigation
A-B	Source tests
C-D	Evaluate control alternatives
D-E	Commit funds for total program
E-F	Procure preliminary control plan and compliance schedule for agency
F-G	Agency review and approval
G-1	Finalize plans and specifications
1-H	Procure control device bids
H-J	Evaluate control device bids
J-2	Award control device contract
2-K	Vendor prepares assembly drawings

Designation	
K-L	Review and approval of assembly drawings
L-M	Vendor prepares fabrication drawings
M-N	Fabricate control device
L-O	Prepare engineering drawings
O-P	Procure construction bids
P-Q	Evaluate construction bids
Q-3	Award construction contract
3-N	On-site construction
N-R	Install control device
R-4	Complete construction (system tie-in)
4-5	Startup, shakedown, preliminary source test

Figure 3.2.3 Schedule for installation of an electrostatic precipitator for particulate pollutant control on a municipal incinerator.



MILESTONES

		ELAPSED TIME (WEEKS)
1	Date of submittal of final control plan to appropriate agency.	4
2	Date of award of control device contract.	19
3	Date of initiation of on-site construction or installation of emission control equipment.	42
4	Date by which on-site construction or installation of emission control equipment is completed.	95
5	Date by which final compliance is achieved.	101

ACTIVITIES

Designation	
A-C	Preliminary investigation
A-B	Source tests
C-D	Evaluate control alternatives
D-E	Commit funds for total program
E-F	Prepare preliminary control plan and compliance schedule for agency
F-G	Agency review and approval
G-I	Finalize plans and specifications
I-H	Procure control device bids
H-J	Evaluate control device bids
J-2	Award control device contract
2-K	Vendor prepares assembly drawings

Designation	
K-L	Review and approval of assembly drawings
L-M	Vendor prepares fabrication drawings
M-N	Fabricate control device
L-O	Prepare engineering drawings
O-P	Procure construction bids
P-Q	Evaluate construction bids
Q-3	Award construction contract
3-N	On-site construction
N-R	Install control device
R-4	Complete construction (system tie-in)
4-5	Startup, shakedown, preliminary source test

3.3 Evaporation Sources

3.3.1 Surface Coating

Process Description - Surface coating operations consist of applying a coat of paint or varnish to an object, evaporating the solvent by application of heat, and finally hardening the coated surface by subjecting it to higher temperatures. Coating operations vary in size from small manually operated units to large auto body spraying and dipping operations. This classification also includes coating and decorating of cans.

Large-scale solvent evaporation and baking operations are conducted inside an oven, where the required heat is supplied by banks of infrared lamps or by direct or indirect combustion of natural gas or fuel oil. During the surface coating and drying operation, most of the volatile constituents of the coated material evaporate and are released to the atmosphere if air pollution control equipment is not used.

Simplified schematics of surface coating operations, with direct-fired afterburner and adsorption systems to control hydrocarbon emissions, are shown in Figures 3.3.1 and 3.3.2. Freshly coated pieces enter the oven, in which the pressure is

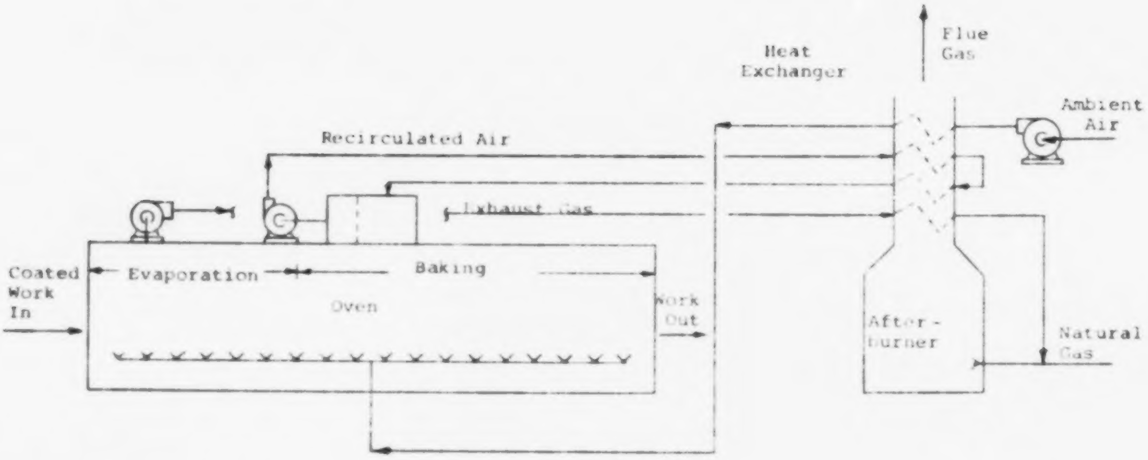

Flue Gas
Heat Exchanger
Ambient Air
Recirculated Air
Exhaust Gas
Coated Work In
Evaporation
Baking
Oven
Work Out
After-burner
Natural Gas

Figure 3.3.1 Surface coating operation with afterburner control system.

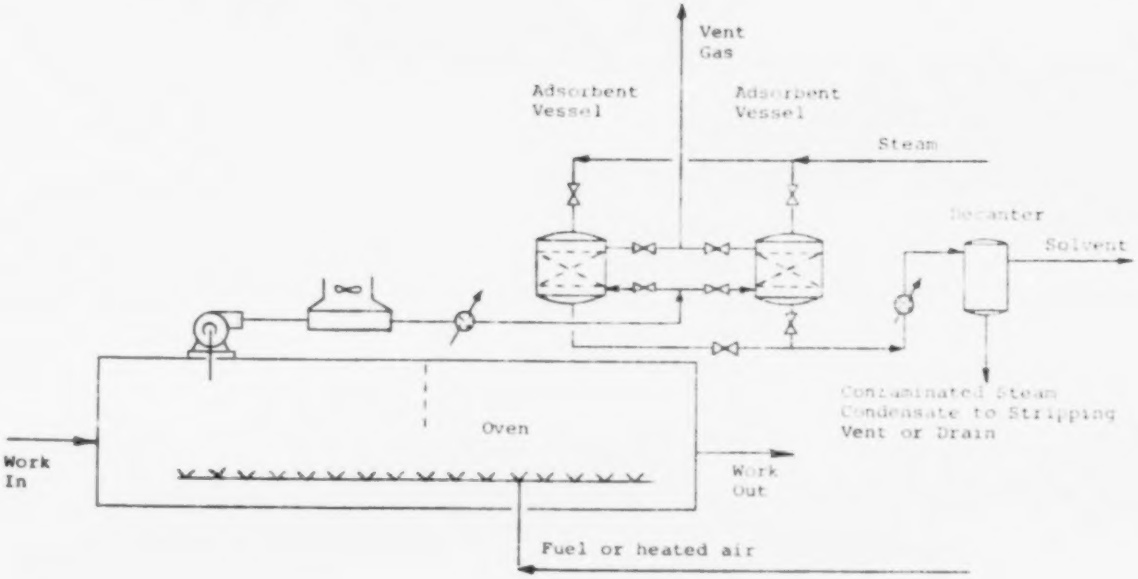

Vent Gas
Adsorbent Vessel
Adsorbent Vessel
Steam
Decanter
Solvent
Contaminated Steam Condensate to Stripping Vent or Drain
Oven
Work In
Work Out
Fuel or heated air

Figure 3.3.2 Surface coating operation with adsorption control system.

maintained slightly below atmospheric conditions to prevent any leakage of solvent vapors into the room and to draw sufficient room air into the oven to prevent the formation of explosive mixtures. Most of the volatile components of the coating are released shortly after entering the oven. This mixture of hydrocarbons and air is withdrawn from the oven by means of a blower.

Atmospheric Emissions - Hydrocarbons from the coating application and drying processes are the primary emissions of concern. Some particulate emissions also occur from the paint spraying operations, but these are generally controlled near the point of application by fiberglass filters and/or a water curtain built into the booth's exhaust system.

The type and quantity of hydrocarbon emissions vary directly with the type and quantity of solvent in the coating. The solvent content often amounts to about 50% of the total weight of the coating material. Overall process emissions can be estimated by material balance calculations, since all of the solvent must evaporate in some part of the process. In direct-fired ovens, however, some solvent vapor is burned.

Control Systems - Hydrocarbon emissions can be minimized by using control equipment or by reducing the solvent content of the coating. The use of "exempt" solvents and water-base coatings, and the setting or drying of coatings by application of other types of energy (eg. infrared, ultraviolet) instead of heat, are process changes that reduce emissions.

Where process changes cannot be made, control equipment such as direct-fired afterburners, catalytic afterburners, and adsorption systems can be used to reduce emissions. Selection of an air pollution control system depends on several factors including the value of the recovered solvent and the availability and cost of fuel oil or natural gas for incineration. Generally, small operations where the flow rate of vented gas is less than 5000 SCFM use direct-fired afterburners without heat recovery. Large operations with emissions in the tens of thousands of SCFM use direct-flame incineration with heat recovery, or catalytic burners. When the solvent is worth recovering, an adsorption system may be incorporated into the process.

Compliance Schedule - Figures 3.3.3 and 3.3.4 illustrate expeditious schedules for installation of a field-erected adsorbtion system and a skid-mounted "package" adsorption system, respectively. The type of system used depends upon such factors as nature of the recovered solvent and volume of vented gas. Figure 3.3.5 represents an expeditious schedule for installation of an afterburner.

Sources of Additional Information

Source	Type of Information*
1. Air Pollution Engineering Manual NTIS No: PB 190 243	P, E, C
2. Afterburner System Study Prepared by Shell Development Company for EPA under Contract EHSD 71-3 Office of Air Programs, Research Triangle Park, North Carolina	C
3. Evaluations of Emissions and Control Technologies in the Graphic Arts Industries NTIS No. PB 195-77C	P, E, C

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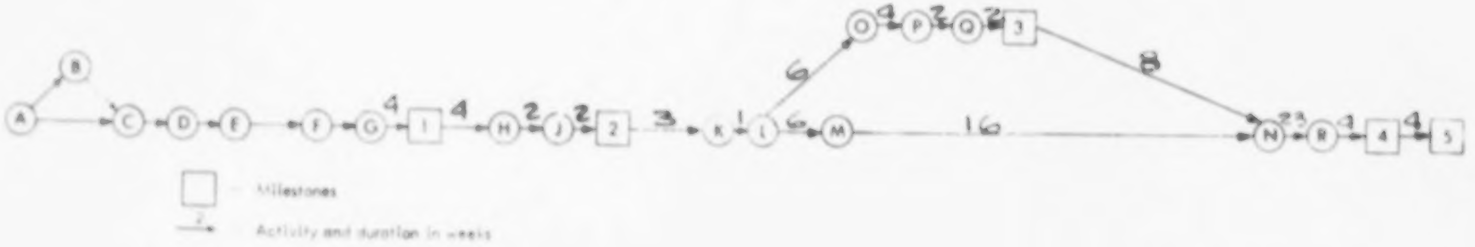
* P = Process description
E = Emission rates
C = Control devices

Figure 3.3.3 Schedule for installation of field-erected absorption system including distillation unit on a surface coating operation for hydrocarbon emissions control.



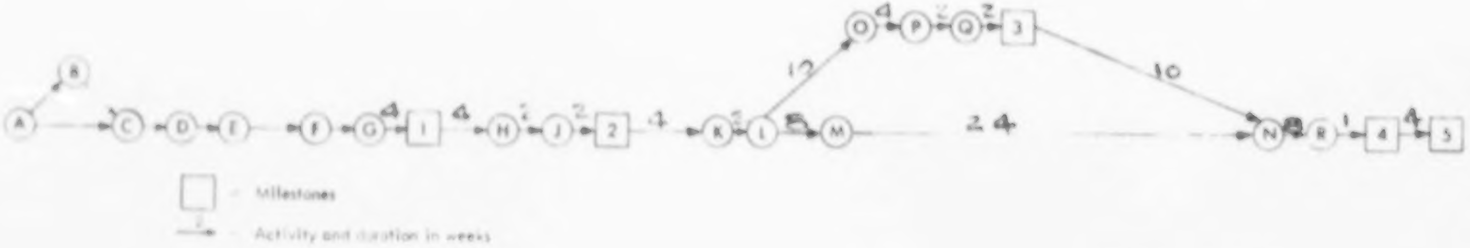
MILESTONES

		ELAPSED TIME (WEEKS)
1	Date of submittal of final control plan to appropriate agency.	4
2	Date of award of control device contract.	12
3	Date of initiation of on-site construction or installation of emission control equipment.	
4	Date by which on-site construction or installation of emission control equipment is completed.	65
5	Date by which final compliance is achieved.	69

ACTIVITIES

Designation		Designation	
A-C	Preliminary investigation	K-L	Review and approval of assembly drawings
A-B	Source tests	L-M	Vendor prepares fabrication drawings
C-D	Evaluate control alternatives	M-N	Fabricate control device
D-E	Commit funds for total program	L-O	Prepare engineering drawings
E-F	Prepare preliminary control plan and compliance schedule for agency	O-P	Procure construction bids
F-G	Agency review and approval	P-Q	Evaluate construction bids
G-1	Finalize plans and specifications	Q-3	Award construction contract
1-H	Procure control device bids	3-N	On-site construction
H-J	Evaluate control device bids	N-R	Install control device
J-2	Award control device contract	R-4	Complete construction (system tie-in)
2-K	Vendor prepares assembly drawings	4-5	Startup, shakedown, preliminary source test

Figure 3.3.4 Schedule for installation of a packaged adsorption system including field-erected distillation unit on a surface coating operation for hydrocarbon emissions control.



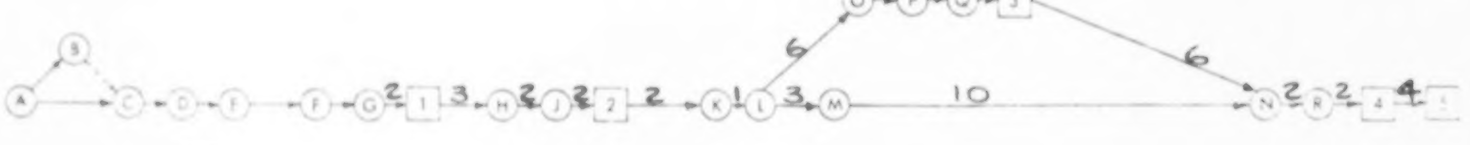
MILESTONES

		ELAPSED TIME (WEEKS)
1	Date of submittal of final control plan to appropriate agency.	4
2	Date of award of control device contract.	12
3	Date of initiation of on-site construction or installation of emission control equipment.	36
4	Date by which on-site construction or installation of emission control equipment is completed.	59
5	Date by which final compliance is achieved.	63

ACTIVITIES

Designation		Designation	
A-C	Preliminary investigation	K-L	Review and approval of assembly drawings
B-C	Source tests	L-M	Vendor prepares fabrication drawings
C-D	Evaluate control alternatives	M-N	Fabricate control device
D-E	Commit funds for total program	L-O	Prepare engineering drawings
E-F	Prepare preliminary control plan and compliance schedule for agency	O-P	Procure construction bids
F-G	Agency review and approval	P-Q	Evaluate construction bids
G-1	Finalize plans and specifications	Q-3	Award construction contract
1-H	Procure control device bids	3-N	On-site construction
H-J	Evaluate control device bids	N-R	Install control device
J-2	Award control device contract	R-4	Complete construction (system tie-in)
2-K	Vendor prepares assembly drawings	4-5	Startup, shakedown, preliminary source test

Figure 3.3.5 Schedule for installation of an afterburner on a surface coating operation for hydrocarbon emissions control.



☐ = Milestones

$\xrightarrow{2}$ = Activity and duration in weeks

MILESTONES

		ELAPSED TIME (WEEKS)
1	Date of submittal of final control plan to appropriate agency.	2
2	Date of award of control device contract.	9
3	Date of initiation of on-site construction or installation of emission control equipment.	26
4	Date by which on-site construction or installation of emission control equipment is completed.	36
5	Date by which final compliance is achieved.	40

ACTIVITIES

Designation		Designation	
A-C	Preliminary investigation	K-L	Review and approval of assembly drawings
A-B	Source tests	L-M	Vendor prepares fabrication drawings
C-D	Evaluate control alternatives	M-N	Fabricate control device
D-E	Commit funds for total program	L-O	Prepare engineering drawings
E-F	Prepare preliminary control plan and compliance schedule for agency	O-P	Procure construction bids
F-G	Agency review and approval	P-Q	Evaluate construction bids
G-1	Finalize plans and specifications	Q-3	Award construction contract
1-H	Procure control device bids	3-N	On-site construction
H-J	Evaluate control device bids	N-R	Install control device
J-2	Award control device contract	R-4	Complete construction (system tie-in)
2-K	Vendor prepares assembly drawings	4-5	Startup, shakedown, preliminary source test

3.3.2 Petroleum Storage

Process Description - Storage vessels can be classified as either closed-storage or open-storage tanks. Pressure vessels used for storage of volatile hydrocarbons are most commonly cylinders, spheres, or spheroids. Closed vessels for less volatile fractions are normally fixed-roof tanks, floating-roof tanks, or conservation tanks. Normally fixed-roof tanks or lifted-roof conservation tanks are used for low volatility liquids. Floating-roof tanks and diaphragm conservation tanks minimize the vapor space and are normally used for volatile fractions or for hydrocarbons that present potential hazards for fire or explosion.

Open-storage vessels, found in a variety of shapes, are now used infrequently because of safety and product conservation considerations.

Atmospheric Emissions - Hydrocarbon vapors are emitted as a result of volatilization of the stored material. Since cylindrical flat-roof tanks operate at only a very slight positive pressure, the diurnal atmospheric temperature changes cause expansion and contraction of the tank vapor space, and hence emissions or "breathing". Emissions are particularly significant in fixed-roof tanks since filling also causes breathing.

Control Systems - Effective control methods include the use of floating roofs, reducing either the exposed surface area or the tank volume with devices such as plastic blankets and spheres, and vapor recovery systems. Installation of an internal floating roof is the most commonly used control technique for existing tankage.

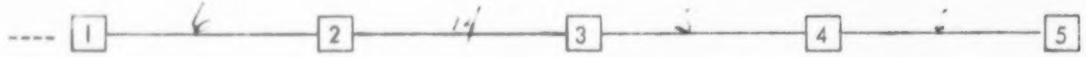
Compliance Schedules - Figure 3.3.6 represents an expeditious schedule for installation of a floating-roof with a double deck on a existing storage tank.

Sources of Additional Information

Source	Type of Information*
1. Air Pollution Engineering Manual PHS Publication No. 999 AP-40	P, E, C
2. Petroleum Refinery Engineering W.L. Nelson, McGraw-Hill, 1958	P, C
3. Atmospheric Emissions from Petroleum Refineries - A Guide for Measurement and Control NTIS No. PB 198-096	E

* P = Process description
E = Emission rates
C = Control devices

Figure 3.3.6 Schedule for installation of an internal floater on an existing storage tank for hydrocarbon emissions control*.



MILESTONES		ELAPSED TIME (WEEKS)
1	Date of submittal of final control plan to appropriate agency.	4
2	Date of award of control device contract.	[illegible]
3	Date of initiation of on-site construction or installation of emission control equipment.	24
4	Date by which on-site construction of emission control equipment is completed.	29
5	Date by which final compliance is achieved.	31

ACTIVITIES

DESIGNATIONS	
1 - 2	Preparation of detailed engineering and fabrication drawings, equipment specifications, construction bid documents and award of construction contract.
2 - 3	Equipment fabrication and delivery of structural components to site.
3 - 4	Delivery of remaining equipment and completion of construction including process tie in.
4 - 5	Equipment start up and source testing.

*Note: For tanks 150 to 200 ft. in diameter, add 10 weeks to Steps 3-4.

3.4 Chemical Processes

3.4.1 Nitric Acid

Process Description - All nitric acid produced commercially is manufactured by the ammonia oxidation process. Despite many variations in operating details among the plants producing nitric acid, three basic steps are common to all: (1) oxidation of ammonia to nitric oxide, followed by (2) oxidation of nitric oxide to the dioxide, and finally (3) absorption of nitrogen dioxide in water to produce nitric acid with the release of additional nitric oxide.

A schematic flow diagram for production of nitric acid by the ammonia oxidation pressure process is shown in Figure 3.4.1. In this process ammonia vapors are mixed with preheated compressed air and are passed over a platinum catalyst to form nitrogen oxide and water. The heat content of the gas, primarily due to the exothermic reaction, is recovered by preheating the absorber tail gases and the process air, and finally by passing the gas through a waste heat boiler to generate steam. The gases are then filtered to recover the valuable platinum catalyst dust and further cooled in a water cooler. The successive oxidations and hydrations of the nitric oxide are conducted with continuous water cooling in a stainless steel absorption tower.

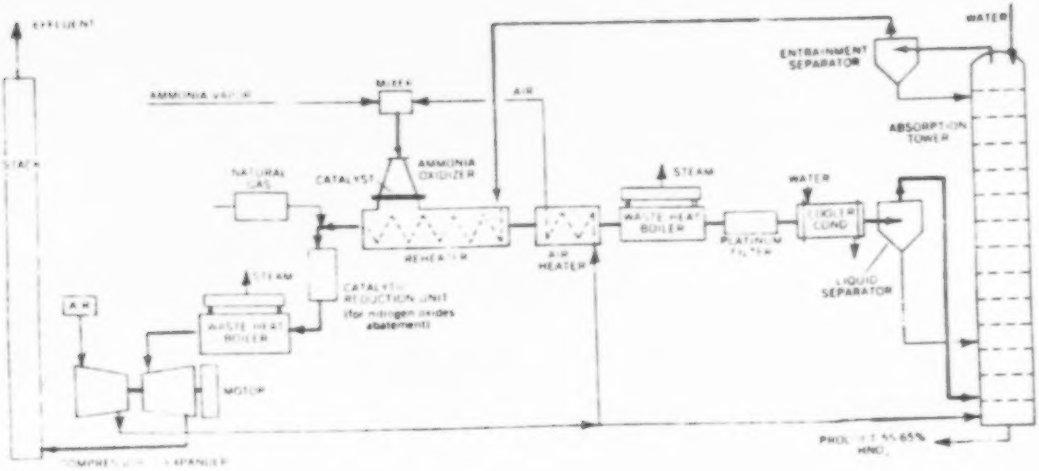

EFFLUENT
STACK
AMMONIA VAPOR
MIXER
AIR
CATALYST
AMMONIA OXIDIZER
NATURAL GAS
REHEATER
STEAM
CATALYTIC REDUCTION UNIT
(for nitrogen oxides abatement)
AIR
WASTE HEAT BOILER
MOTOR
COMPRESSOR
EXPANDER
AIR HEATER
STEAM
WASTE HEAT BOILER
PLATINUM FILTER
WATER
COOLER COND
LIQUID SEPARATOR
ENTRAINMENT SEPARATOR
WATER
ABSORPTION TOWER
PRODUCT 55-65% HNO3

Figure 3.4.1 Flow diagram of nitric acid manufacture by the pressure process, with catalytic tail gas control system.

The tail gas leaving the absorption tower normally contains 0.2 to 0.3 percent nitrogen oxides by volume. In an uncontrolled plant these gases are vented, after passing through an expander turbine for energy recovery.

Atmospheric Emissions - Emissions of nitrogen oxides from nitric acid plants are estimated to be about 43 pounds per ton of acid produced. This corresponds to about 3000 ppm NO_x (by volume) in the exit gas stream. Nitrogen dioxide, distinguished by its opaque reddish-brown color, makes up approximately 50 percent of this emission. The remainder of the gas is the colorless nitric oxide compound.

Control Systems - Equipment for nitrogen oxides control includes catalytic reduction, molecular sieve adsorption systems, and caustic scrubbers. Catalytic reduction can reduce emissions by 36 to 99 percent (80 percent average) depending on design, fuel input, and operating temperatures. The molecular sieve system provides efficiency of over 99 percent, but has only recently been applied to full-size systems. Caustic scrubbers are used only under special circumstances (e.g. where there is a market for recovered byproducts).

Compliance Schedules - Figures 3.4.2 and 3.4.3 illustrate, respectively, expeditious schedules for installations of catalyt reduction unit with heat recovery and molecular sieve adsorption system. At present, molecular sieve systems are being installed on two nitric acid plants. Because no nitric acid plant is operating with molecular sieves, the schedule is tentative.

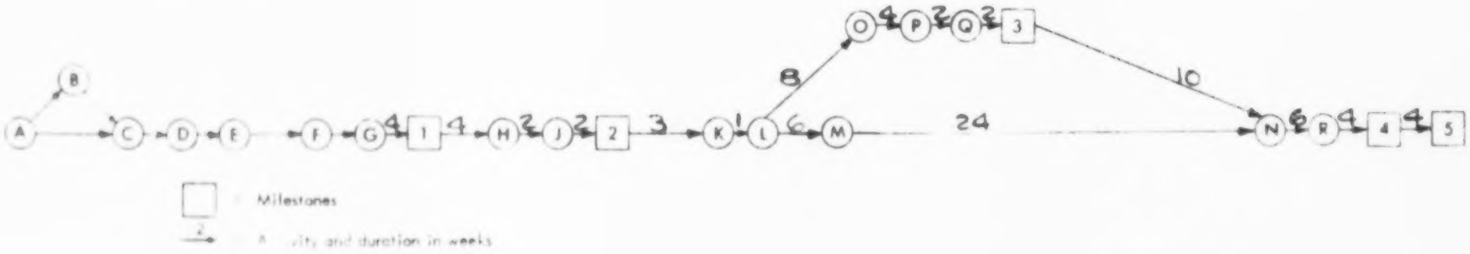
Sources of Additional Information

Source	Type of Information*
1. Kirk-Othmer's Encyclopedia of Chemical Technology Volume 13, 2nd edition	P
2. Atmospheric Emissions from Nitric Acid Manufacturing Processes. PHS Publication No. 999-AP-27	P, E, C

3. Background Information for Proposed New-Source Performance Standards: Steam Generators, Incinerators, Portland Cement Plants, Nitric Acid Plants, and Sulfuric Acid Plants NTIS No. PB 202-459	E, C
4. Air Pollution Aspects of Emission Sources: Nitric Acid Manufacturing Publication No. AP-093	E, C

* P = Process description
E = Emission rates
C = Control system

Figure 3.4.2 Schedule for installation of a catalytic reduction unit with waste heat recovery on a nitric acid plant for nitrogen oxide emissions control.



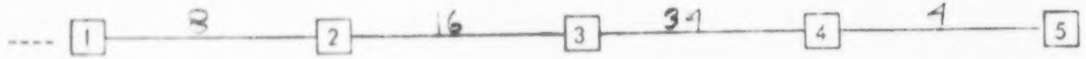
MILESTONES

		ELAPSED TIME (WEEKS)
1	Date of submittal of final control plan to appropriate agency.	4
2	Date of award of control device contract.	12
3	Date of initiation of on-site construction or installation of emission control equipment.	32
4	Date by which on-site construction or installation of emission control equipment is completed.	56
5	Date by which final compliance is achieved.	60

ACTIVITIES

Designation		Designation	
A-C	Preliminary investigation	K-L	Review and approval of assembly drawings
A-B	Source tests	L-M	Vendor prepares fabrication drawings
C-D	Evaluate control alternatives	M-N	Fabricate control device
D-E	Commit funds for total program	L-O	Prepare engineering drawings
E-F	Prepare preliminary control plan and compliance schedule for agency	O-P	Procure construction bids
F-G	Agency review and approval	P-Q	Evaluate construction bids
G-1	Finalize plans and specifications	Q-3	Award construction contract
1-H	Procure control device bids	3-N	On-site construction
H-J	Evaluate control device bids	N-R	Install control device
J-2	Award control device contract	R-4	Complete construction (system tie-in)
2-K	Vendor prepares assembly drawings	4-5	Startup, shakedown, preliminary source test

Figure 3.4.3 Tentative schedule for installation of molecular sieve adsorption system of a nitric acid plant for nitrogen oxide emissions control.



MILESTONES		ELAPSED TIME (WEEKS)
1	Date of submittal of final control plan to appropriate agency.	4
2	Date of award of control device contract.	12
3	Date of initiation of on-site construction or installation of emission control equipment.	28
4	Date by which on-site construction of emission control equipment is completed.	62
5	Date by which final compliance is achieved.	66

ACTIVITIES

DESIGNATIONS	
1 - 2	Preparation of detailed engineering and fabrication drawings, equipment specifications, construction bid documents and award of construction contract.
2 - 3	Equipment fabrication and delivery of structural components to site.
3 - 4	Delivery of remaining equipment and completion of construction including process tie in.
4 - 5	Equipment start up and source testing.

3.4.2 Phosphoric Acid

Process Description - Phosphoric acid is produced by two basic methods, the wet process and the thermal process. In the wet process, phosphate rock is treated with sulfuric acid. The ensuing chemical reactions result in the formation of phosphoric acid and the precipitation of calcium sulfate. The latter is filtered off, and the acid is concentrated from about 32 percent P_2O_5 to about 54 percent P_2O_5. A simplified flow diagram is shown in Figure 3.4.4.

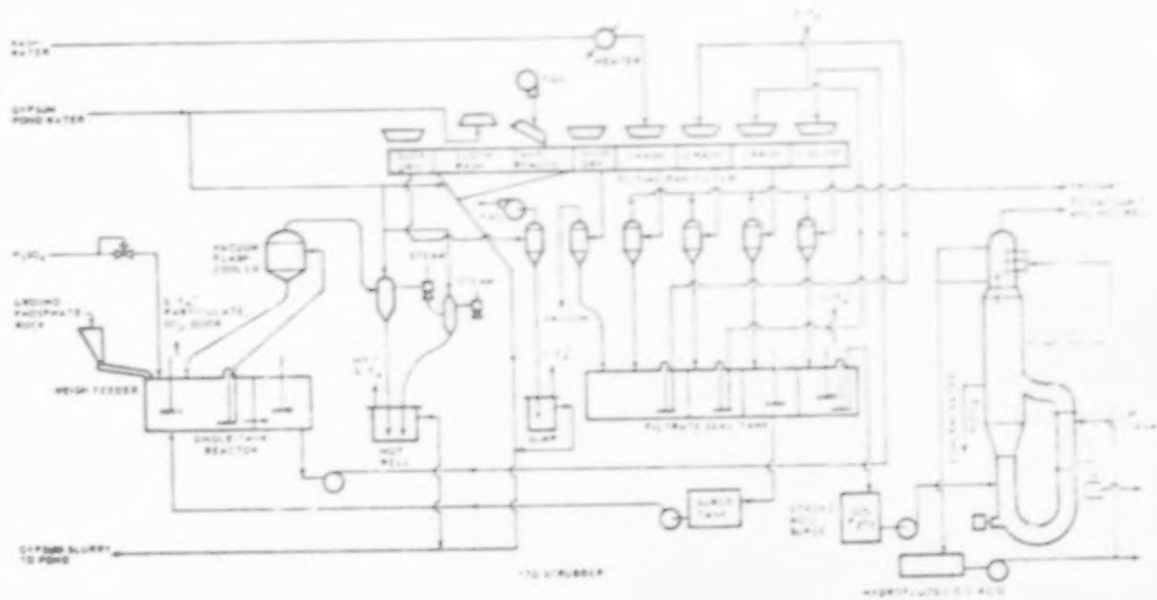

RAW WATER
GYPSUM POND WATER
HEATER
FAN
H_2SO_4
VACUUM FLASH COOLER
GROUND PHOSPHATE ROCK
WEIGH FEEDER
SINGLE-TANK REACTOR
STEAM
HOT WELL
SUMP
FILTRATE SEAL TANK
SURGE TANK
GYPSUM SLURRY TO POND
TO SCRUBBER
HYDROFLUOSILICIC ACID

Figure 3.4.4 Wet-process phosphoric acid plant.

In the thermal process, phosphoric acid is produced from elemented phosphorous. Three basic steps are involved: (1) burning the molten phosphorus in a suitable chamber to produce phosphorus partoxide; (2) hydrating the phosphoric acid and mist; (3) removal of the phosphoric acid mist from the gas stream. A simplified flow diagram of the major steps in the manufacture of phosphoric acid by the thermal process is shown in Figure 3.4.5.

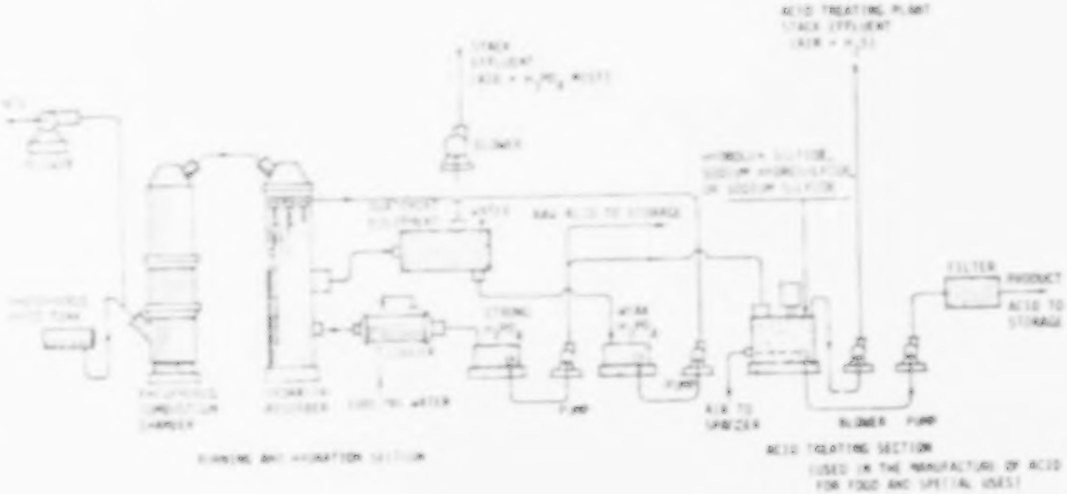

ACID TREATING PLANT
STACK EFFLUENT
(AIR + H_2S)
STACK
EFFLUENT
(AIR + H_3PO_4 MIST)
BLOWER
BLOWER
HYDROGEN SULFIDE,
SODIUM HYDROSULFIDE,
OR SODIUM SULFIDE
WATER
RAW ACID TO STORAGE
FILTER
PRODUCT
ACID TO
STORAGE
STRONG
H_3PO_4
WEAK
H_3PO_4
PUMP
PUMP
COOLING WATER
PHOSPHORUS
COMBUSTION
CHAMBER
HYDRATOR
ABSORBER
AIR TO
SPARGER
BLOWER
PUMP
BURNING AND HYDRATION SECTION
ACID TREATING SECTION
(USED IN THE MANUFACTURE OF ACID
FOR FOOD AND SPECIAL USES)

Figure 3.4.5 Thermal-process phosphoric acid plant

Atmospheric Emissions - The emissions of most concern in the wet process are the fluorine compounds liberated from the rock by the sulfuric acid. These consist of hydrogen fluoride, silicon tetrafluoride and some products of reaction and decomposition of the latter. Most phosphate rock contains 3.5 to 4 percent fluorine, and half of this may be volatilized in the processing. Fluorides may be emitted from exposed surfaces of reaction slurry, from aqueous solutions of fluorine compounds, and from any evaporation process.

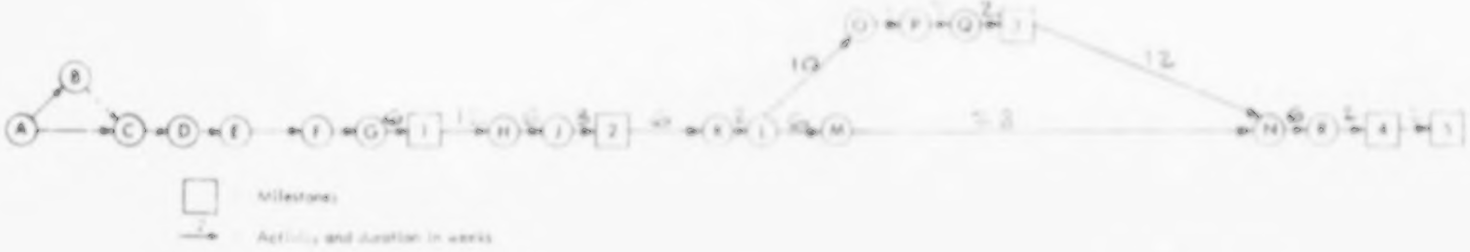
The major atmospheric contaminant from the thermal process is phosphoric acid mist discharged in the absorber exit gas. This gas stream also contains water vapor and trace amounts of nitrogen oxides. Another important emission is the discharge gas from the acid-treating tank. These emissions are intermittent and range from 10 to 2500 parts per million of hydrogen sulfide.

Control Systems - Because the principal atmospheric contaminants generated in the wet process are gaseous fluorides, scrubbing is universally employed to control emissions. Devices used for control include venturi scrubbers, impingement scrubbers, and various kinds of spray towers.

For the thermal process, primary control devices for control of emissions of acid mist include high-pressure wire-mesh eliminators and high-efficiency glass-fiber mist eliminators.

Compliance Schedules - Figure 3.4.6 illustrates an expeditious schedule for installing a wet scrubber system on either a wet or thermal process plant. An expeditious schedule for installation of a high-efficiency mist eliminator is shown in Figure 3.4.7.

Figure 3.4.6 Schedule for installation of wet scrubber system on phosphoric acid manufacturing operation for gaseous and particulate fluoride control.



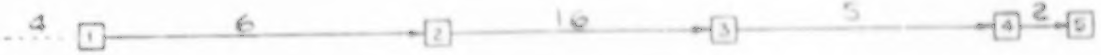
MILESTONES

		ELAPSED TIME (WEEKS)
1	Date of submittal of final control plan to appropriate agency.	[illegible]
2	Date of award of control device contract.	26
3	Date of initiation of on-site construction or installation of emission control equipment.	52
4	Date by which on-site construction or installation of emission control equipment is completed.	74
5	Date by which final compliance is achieved.	76

ACTIVITIES

Designation		Designation	
A-C	Preliminary investigation	K-L	Review and approval of assembly drawings
A-B	Source tests	L-M	Vendor prepares fabrication drawings
C-D	Evaluate control alternatives	M-N	Fabricate control device
D-E	Commit funds for total program	L-O	Prepare engineering drawings
E-F	Prepare preliminary control plan and compliance schedule for agency	O-P	Procure construction bids
F-G	Agency review and approval	P-Q	Evaluate construction bids
G-1	Finalize plans and specifications	Q-3	Award construction contract
1-H	Procure control device bids	3-N	On-site construction
H-I	Evaluate control device bids	N-R	Install control device
I-2	Award control device contract	R-4	Complete construction (system tie-in)
2-K	Vendor prepares assembly drawings	4-5	Startup, shakedown, preliminary source test

Figure 3.4.1 Schedule for installation of high-pressure mist eliminator on phosphoric acid manufacturing operation for acid mist emissions control.



MILESTONES		ELAPSED TIME (WEEKS)
1	Date of submittal of final control plan to appropriate agency.	4
2	Date of award of control device contract.	10
3	Date of initiation of on-site construction or installation of emission control equipment.	26
4	Date by which on-site construction of emission control equipment is completed.	31
5	Date by which final compliance is achieved.	33

ACTIVITIES

DESIGNATIONS	
1 - 2	Preparation of detailed engineering and fabrication drawings, equipment specifications, construction bid documents and award of construction contract.
2 - 3	Equipment fabrication and delivery of structural components to site.
3 - 4	Delivery of remaining equipment and completion of construction including process tie in.
4 - 5	Equipment start up and source testing.

Sources of Additional Information

	Source	Type of Information*
1)	Atmospheric Emissions from Wet-Process Phosphoric Acid Manufacture. NAPCA Publication No. AP-57	P,E,C
2)	Atmospheric Emissions from Thermal-Process Phosphoric Acid Manufacture. NAPCA Publication No. AP-48	P,E,C

* P = Process
E = Emissions
C = Control Devices

3.4.3 Sulfuric Acid

Process Description - Essentially all sulfuric acid is produced by the contact process shown schematically in Figure 3.4.8 for a sulfur burning plant. Sulfur or sulfur-containing raw materials (e.g. spent acid) are burned to form SO_2, which is then catalytically oxidized in a converter to SO_3. The heat liberated in the converter reaction is removed in several stages by intermediate gas cooling. The exit gas from the converter is cooled and the SO_3 is absorbed in a circulating stream of 98 percent H_2SO_4.

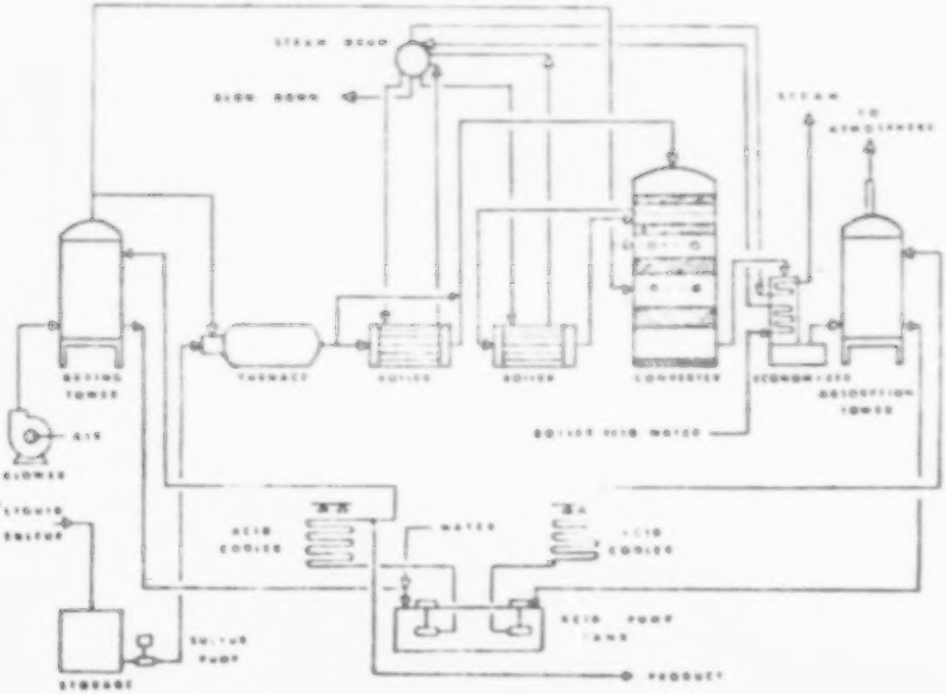

STEAM DRUM
BLOW DOWN
STEAM
TO ATMOSPHERE
DRYING TOWER
FURNACE
BOILER
BOILER
CONVERTER
ECONOMIZER
ABSORPTION TOWER
AIR
BLOWER
BOILER FEED WATER
LIQUID SULFUR
ACID COOLER
WATER
ACID COOLER
ACID PUMP TANK
SULFUR PUMP
STORAGE
PRODUCT

Figure 3.4.8 Contact-process sulfuric acid plant burning elemental sulfur.

Variations in the contact process are due primarily to differences in the sulfur feedstock. Units operating with spent acid, sludge, or tail gas are more complicated than sulfur-burning plants since these are contaminated streams. After burning the feed stream in these "wet gas" plants, the resulting gas stream requires cleaning and cooling to remove dust, acid mist, gaseous impurities, and excessive water vapor. Following gas drying, the process is essentially the same as in an elemental sulfur-burning plant.

Atmospheric Emissions - SO_2 emissions vary inversely with the SO_2 to SO_3 conversion efficiency. For older sulfur-burning plants with three-stage converters, conversion efficiencies are typically 95 to 96 percent, which correspond to emissions of 55 to 70 pounds of SO_2 per ton of acid produced. Conversion efficiencies for four-stage converters range from 96 to 98 percent, with SO_2 emissions between 26 and 55 pounds per ton. Dual absorption plants, discussed under Control Systems, can achieve conversion efficiencies in excess of 99 percent; the resulting SO_2 emissions usually range between 2 and 7 pounds per ton of acid.

Acid mist emissions are also significant, especially for plants producing oleum or using sulfur feed stocks other than elemental sulfur. If uncontrolled, emissions range between

0.5 and 5 pounds per ton of acid produced at sulfur-burning plants, and about 1 to 10 pounds per ton at spent acid plants.

Control Systems - SO_2 emissions can be controlled by use of a dual absorption process, sodium sulfite scrubbing, ammonia solution scrubbing, or molecular sieves. In the dual absorption process, SO_2 emissions are decreased by increasing the SO_2 to SO_3 conversion efficiency. The SO_3 formed in the initial converter stages is removed in a primary absorber, and the remainder of the gas is returned to the converter. The additional SO_3 formed is absorbed in a secondary absorber. The dual absorption configuration can reduce SO_2 emissions to between approximately 2.0 and 7 pounds per ton of acid produced.

Sodium sulfite scrubbing of absorber off-gas can reduce SO_2 emissions to between 2.0 and 3.0 pounds per ton. The recovered SO_2 is normally recycled to the acid plant. Ammonia solution scrubbing can reduce SO_2 emissions to approximately 100 ppm. Spent scrubbing liquor is either used to produce ammonium sulfate or thermally decomposed to recycle SO_2 to the acid plant. A multi-stage scrubber and a high-efficiency particulate collection device are normally required to minimize ammonia losses and to prevent a visible plume caused by ammonium salts.

Molecular sieve separation is capable of reducing SO_2 emissions to between 50 and 100 ppm. The recovered SO_2 is recycled to the acid plant.

Acid mist emissions are usually controlled by use of electrostatic precipitators or mist eliminators. Mist eliminators are generally preferred because of their higher collection efficiency and hence their ability to operate with zero visible discharge.

Compliance Schedules - Figure 3.4.9 illustrates an expeditious schedule for modifying an existing plant to use the dual absorption process. Figures 3.4.10 and 3.4.11 illustrate expeditious schedules for installation of sodium sulfite and ammonium solution scrubbing processes, respectively; the schedule for the ammonium solution scrubbing process incorporates the time required for simultaneous installation of a high-efficiency particulate control device. An approximate time schedule for installation of a molecular sieve separation process is shown in Figure 3.4.12. Since this process has only recently started in commercial operation, this schedule is tentative.

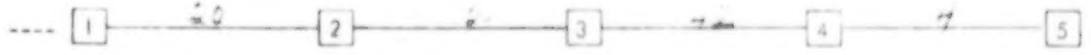
Figure 3.4.13 illustrates an expeditious schedule for installation of a mist eliminator for controlling acid mist emissions.

Sources of Additional Information

Source	Type of Information*
1) Engineering Analysis of Emissions Control Technology for Sulfuric Acid Manufacturing Processes NTIS No. PB 190-393	P, E, C
2) Background Information for Proposed New-Source Performance Standards: Steam Generators, Incinerators, Portland Cement Plants, Nitric Acid Plants, and Sulfuric Acid Plants NTIS No. PB 202-459	P, E, C
3) Atmospheric Emissions from Sulfuric Acid Manufacturing Processes PHS Publication No. 999-AP-13	P, E, C
4) Duecker, W. W. and J. J. West, Manufacture of Sulfuric Acid A.C.S. Mono. 144, Reinhold Pub. Co., New York, N. Y., 1959	P
5) Air Pollution Aspects of Emission Sources: Sulfuric Acid Manufacturing NTIS No. 200-079	E, C

* P = Process description
E = Emission rates
C = Control devices

Figure 3.4.9 Schedule for modifying an existing sulfuric acid plant to the dual absorption process for sulfur oxides emission control.

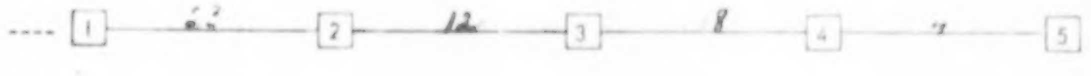


MILESTONES		ELAPSED TIME (WEEKS)
1	Date of submittal of final control plan to appropriate agency.	4
2	Date of award of control device contract.	24
3	Date of initiation of on-site construction or installation of emission control equipment.	36
4	Date by which on-site construction of emission control equipment is completed.	[illegible]
5	Date by which final compliance is achieved.	82

ACTIVITIES

DESIGNATIONS	
1 - 2	Preparation of detailed engineering and fabrication drawings, equipment specifications, construction bid documents and award of construction contract.
2 - 3	Equipment fabrication and delivery of structural components to site.
3 - 4	Delivery of remaining equipment and completion of construction including process tie in.
4 - 5	Equipment start up and source testing.

Figure 3.4.10 Schedule for installation of a sodium sulfite scrubbing system for sulfur oxides emission control.

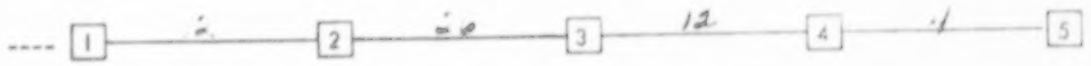


MILESTONES		ELAPSED TIME (WEEKS)
1	Date of submittal of final control plan to appropriate agency.	[illegible]
2	Date of award of control device contract.	[illegible]
3	Date of initiation of on-site construction or installation of emission control equipment.	39
4	Date by which on-site construction of emission control equipment is completed.	[illegible]
5	Date by which final compliance is achieved.	61

ACTIVITIES

DESIGNATIONS	
1 - 2	Preparation of detailed engineering and fabrication drawings, equipment specifications, construction bid documents and award of construction contract.
2 - 3	Equipment fabrication and delivery of structural components to site.
3 - 4	Delivery of remaining equipment and completion of construction including process tie in.
4 - 5	Equipment start up and source testing.

Figure 3.4.11 Schedule for installation of an ammonia scrubbing system, including mist eliminator, on a sulfuric acid plant for sulfur oxides emission control.

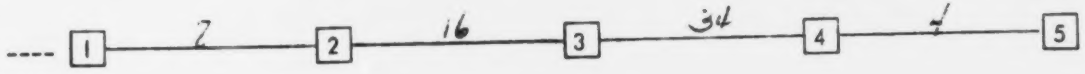


MILESTONES		ELAPSED TIME (WEEKS)
1	Date of submittal of final control plan to appropriate agency.	1
2	Date of award of control device contract.	16
3	Date of initiation of on-site construction or installation of emission control equipment.	42
4	Date by which on-site construction of emission control equipment is completed.	54
5	Date by which final compliance is achieved.	58

ACTIVITIES

DESIGNATIONS	
1 - 2	Preparation of detailed engineering and fabrication drawings, equipment specifications, construction bid documents and award of construction contract.
2 - 3	Equipment fabrication and delivery of structural components to site.
3 - 4	Delivery of remaining equipment and completion of construction including process tie in.
4 - 5	Equipment start up and source testing.

Figure 3.4.12 Tentative schedule for installation of a molecular sieve separation process on a sulfuric acid plant for sulfur oxides emission control.

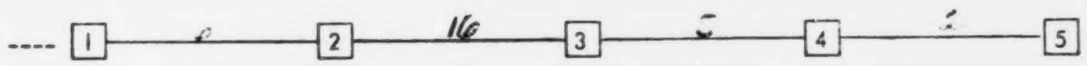


MILESTONES		ELAPSED TIME (WEEKS)
1	Date of submittal of final control plan to appropriate agency.	4
2	Date of award of control device contract.	12
3	Date of initiation of on-site construction or installation of emission control equipment.	28
4	Date by which on-site construction of emission control equipment is completed.	62
5	Date by which final compliance is achieved.	66

ACTIVITIES

DESIGNATIONS	
1 - 2	Preparation of detailed engineering and fabrication drawings, equipment specifications, construction bid documents and award of construction contract.
2 - 3	Equipment fabrication and delivery of structural components to site.
3 - 4	Delivery of remaining equipment and completion of construction including process tie in.
4 - 5	Equipment start up and source testing.

Figure 3.4.13 Schedule for installation of a mist eliminator on a sulfuric acid plant for acid mist emission control.



MILESTONES		ELAPSED TIME (WEEKS)
1	Date of submittal of final control plan to appropriate agency.	4
2	Date of award of control device contract.	
3	Date of initiation of on-site construction or installation of emission control equipment.	[illegible]
4	Date by which on-site construction of emission control equipment is completed.	[illegible] *
5	Date by which final compliance is achieved.	[illegible]

ACTIVITIES

DESIGNATIONS	
1 - 2	Preparation of detailed engineering and fabrication drawings, equipment specifications, construction bid documents and award of construction contract.
2 - 3	Equipment fabrication and delivery of structural components to site.
3 - 4	Delivery of remaining equipment and completion of construction including process tie in.
4 - 5	Equipment start up and source testing.

* 52 weeks if booster blower required.

3.4.4 Paint and Varnish

Process Description - The manufacture of paint involves dispersing a colored oil or pigment into a vehicle, usually a resin or oil, and adding either a hydrocarbon solvent or water to lower the viscosity of the paint for ease of application. Only physical processes are involved; no chemical reactions take place.

The manufacture of varnish also involves the mixing and blending of various ingredients. In this process, however, chemical reactions are initiated by cooking the varnish in open or closed gas-fired kettles for 4 to 16 hours at temperatures between 200 and 650°F.

Atmospheric Emissions - Particulates can be emitted from the handling of dry pigments. The quantity emitted varies with the care taken in handling and with the method of transferring the dry material. Typical emission values range from 0.5 to 1.0 percent of the pigment handled.

Emissions of hydrocarbons, the pollutants of primary concern, are due to the use of organic solvents. Depending on the cooking time and temperature, type of solvent, and type of enclosure, hydrocarbon emissions from varnish cooking range from 20 to 160 pounds per ton of product. The corresponding hydrocarbon emission rate for paint manufacture is approximately 30 pounds per ton of paint produced.

Control Systems - Catalytic oxidation and direct-flame incineration are used to control hydrocarbon emissions from paint and varnish plants. With catalytic units, the collected process off-gases and vapors are heated by combustion of fuel to approximately 600 to 800°F. They are then passed through the catalyst bed, where oxidation of the hydrocarbons further increases the temperature. In thermal incineration units, the temperature is raised to 1200° to 1500°F for residence times between 0.25 and 0.5 second. In both types of units, the hydrocarbons are oxidized to CO_2 and water vapor.

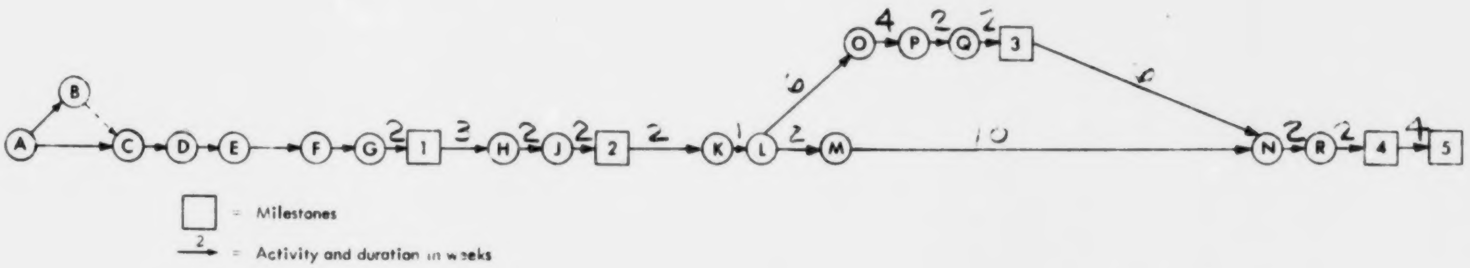
Compliance Schedules - Figure 3.4.14 illustrates an expeditious schedule for installation of an afterburner.

Sources of Additional Information

	Source	Type of Information*
1)	Encyclopedia of Chemical Technology Kirk-Othmer's Vol. 14, 2nd Edition	P,C
2)	Exhaust Gases from Combustion and Industrial Processes NTIS Publication PB 204-861	E
3)	Air Pollution Engineering Manual PHS Publication No. 999-AP-40	P,E,C

* P = Process description
E = Emission rates
C = Control devices

Figure 3.4.14 Schedule for installation of an afterburner on paint or varnish operations for hydrocarbon emissions control.



MILESTONES

		ELAPSED TIME (WEEKS)
1	Date of submittal of final control plan to appropriate agency.	2
2	Date of award of control device contract.	9
3	Date of initiation of on-site construction or installation of emission control equipment.	26
4	Date by which on-site construction or installation of emission control equipment is completed.	36
5	Date by which final compliance is achieved.	40

ACTIVITIES

Designation	
A-C	Preliminary investigation
A-B	Source tests
C-D	Evaluate control alternatives
D-E	Commit funds for total program
E-F	Prepare preliminary control plan and compliance schedule for agency
F-G	Agency review and approval
G-1	Finalize plans and specifications
1-H	Procure control device bids
H-J	Evaluate control device bids
J-2	Award control device contract
2-K	Vendor prepares assembly drawings

Designation	
K-L	Review and approval of assembly drawings
L-M	Vendor prepares fabrication drawings
M-N	Fabricate control device
L-O	Prepare engineering drawings
O-P	Procure construction bids
P-Q	Evaluate construction bids
Q-3	Award construction contract
3-N	On-site construction
N-R	Install control device
R-4	Complete construction (system tie-in)
4-5	Startup, shakedown, preliminary source test

3.4.5 Soap and Detergents

Process Description - Present commercial methods for the manufacture of soap consist primarily of catalytic hydrolysis of various fatty acids with sodium or potassium hydroxide to form a glycerol-soap mixture. This mixture undergoes separation through distillation, followed by neutralization and blending to produce different grades of soap. Soap is finished in many forms, such as bars, flakes, granules, liquids, and powder.

In the manufacture of soap in powder form, the material is spray dried. Prior to spray drying, additives to complete the formulation are suspended or dissolved in the hot soap and the mixture is then pumped through nozzles near the top of a spray tower. Hot air circulated through the tower evaporates water from the spray, forming the powdered soap. A schematic flow diagram for the manufacture of soap is shown in Figure 3.4.15

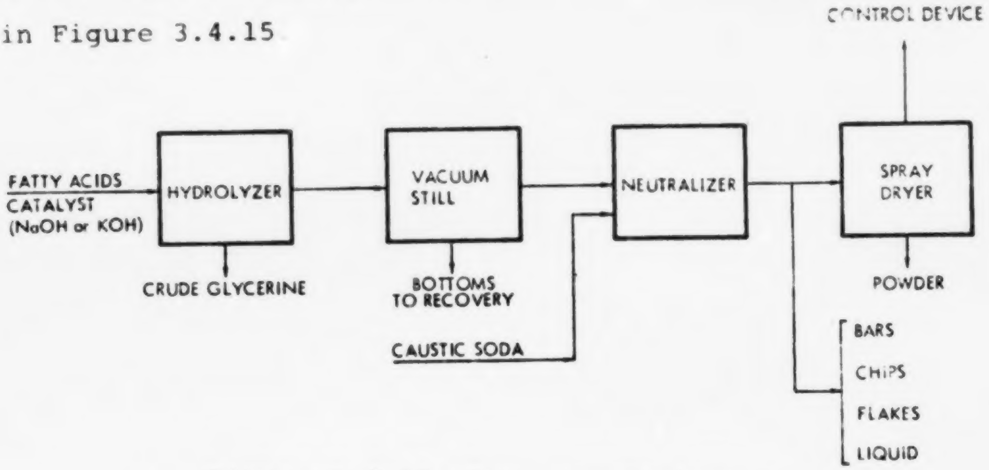

CONTROL DEVICE
FATTY ACIDS
CATALYST (NaOH or KOH)
HYDROLYZER
VACUUM STILL
NEUTRALIZER
SPRAY DRYER
CRUDE GLYCERINE
BOTTOMS TO RECOVERY
CAUSTIC SODA
POWDER
BARS
CHIPS
FLAKES
LIQUID

Figure 3.4.15 Soap manufacture.

In the manufacture of synthetic detergents, fatty alcohols or linear alkylate compounds are first treated with sulfuric acid. The sulfonated compounds are then neutralized with caustic solution, and various dyes, perfumes, and other compounds are added. The resulting paste or slurry is pumped to the top of a drying tower and sprayed through nozzles to form small droplets. As the droplets descend, the moisture content is reduced by the countercurrent hot air flow. The dried detergent is then cooled and packaged. A simplified flow diagram for the manufacture of detergent granules is shown in Figure 3.4.16.

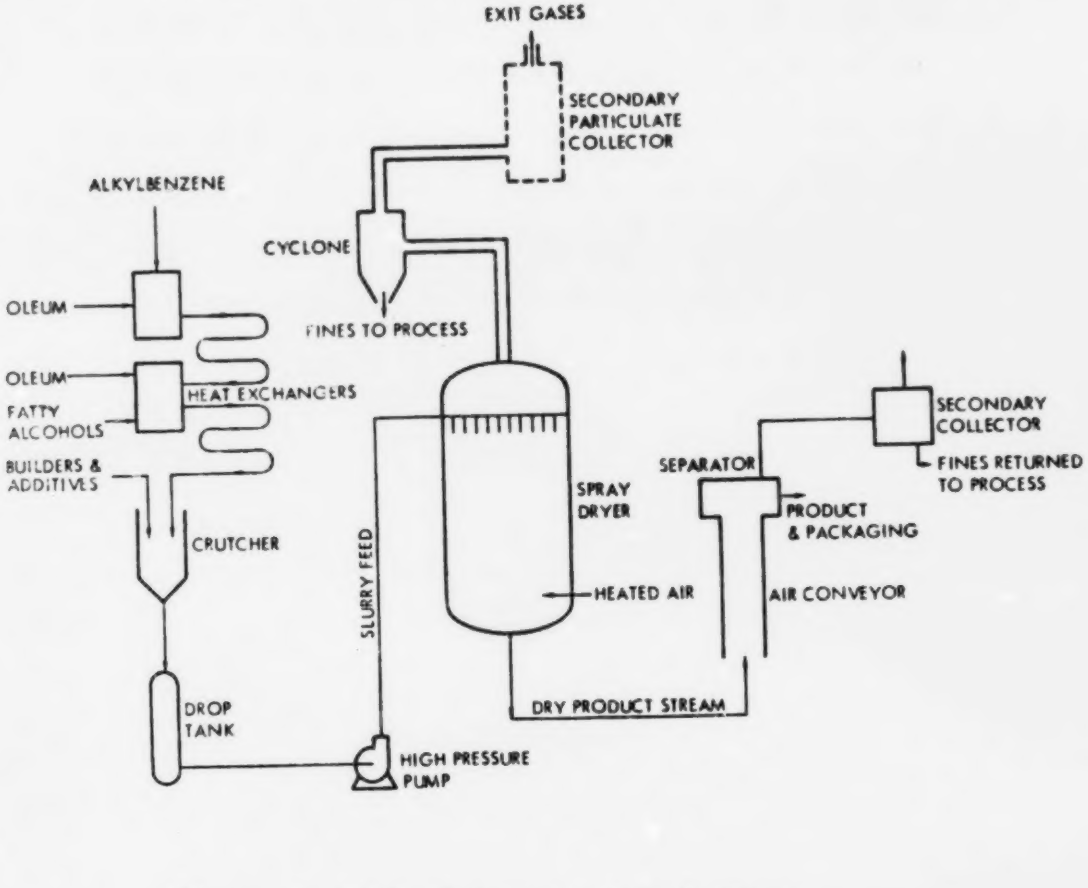

EXIT GASES
SECONDARY PARTICULATE COLLECTOR
ALKYLBENZENE
CYCLONE
OLEUM
FINES TO PROCESS
OLEUM
HEAT EXCHANGERS
FATTY ALCOHOLS
BUILDERS & ADDITIVES
SECONDARY COLLECTOR
FINES RETURNED TO PROCESS
SEPARATOR
SPRAY DRYER
PRODUCT & PACKAGING
CRUTCHER
SLURRY FEED
HEATED AIR
AIR CONVEYOR
DROP TANK
DRY PRODUCT STREAM
HIGH PRESSURE PUMP

Figure 3.4.16 Detergent manufacture.

Atmospheric Emissions - Odors are the emissions of primary concern from soap manufacture. The severity of odorous emissions depends upon the type of feed material used. Low-grade stocks obtained from rendered grease and fats tend to be odoriferous. Local dust emissions can also occur during blending, mixing, and packaging of the finished soap. Spray dryers, if uncontrolled, can be a major source of particulate emissions.

Emissions from synthetic detergent manufacture can be classified as those resulting from the preparation of the synthetic feed compounds from petrochemical stock and those resulting from the final detergent-making operation. The former are essentially hydrocarbons emitted from relief valves, from storage vessels, and from atmospheric and vacuum fractionation operations. The latter come primarily from the spray drier. Uncontrolled particulate emissions from the spray drier are approximately 90 pounds per ton of product. Particulates can also be emitted from various handling and packaging operations, although these are usually controlled because of the product's value.

Control Systems - Particulate and odor emissions from the spray drying of soap or detergent are commonly controlled by a wet scrubber followed by an electrostatic precipitator, if necessary. The stack gases are sometimes reheated to eliminate what otherwise would be a visible plume.

Dust from blending, mixing, and packaging operations can be controlled by collection in a fabric filter. Hydrocarbon emissions from relief valves and fractionation towers can be controlled by incineration.

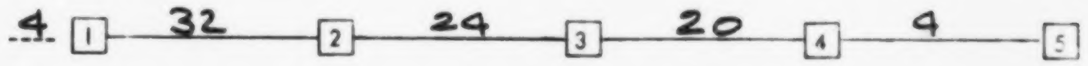
Compliance Schedules - Figures 3.4.17 and 3.4.18 illustrate, respectively, expeditious schedules for installation of a wet scrubber/electrostatic precipitator system on a spray drying tower and a fabric filter on blending and packaging operations.

Sources of Additional Information

Source	Type of Information*
1. Air Pollution Engineering Manual PHS Publication No. 999-AP-40	P, E, C
2. Kirk Othmer's Encyclopedia of Chemical Technology 2nd Edition, Volume 18	P

* P = Process description
E = Emission rates
C = Control devices

Figure 3.4.17 Schedule for installation of a wet scrubber/electrostatic precipitator on a spray drying tower for particulate pollutant control.

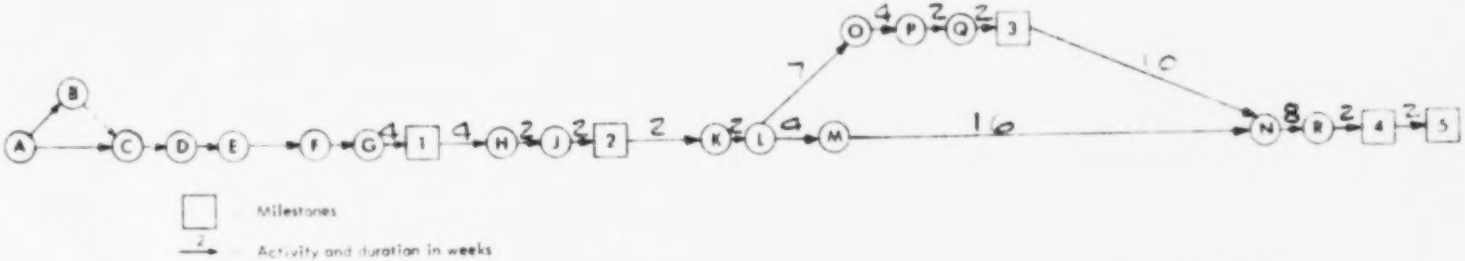


MILESTONES		ELAPSED TIME (WEEKS)
1	Date of submittal of final control plan to appropriate agency.	4
2	Date of award of control device contract.	36
3	Date of initiation of on-site construction or installation of emission control equipment.	60
4	Date by which on-site construction of emission control equipment is completed.	80
5	Date by which final compliance is achieved.	84

ACTIVITIES

DESIGNATIONS	
1 - 2	Preparation of detailed engineering and fabrication drawings, equipment specifications, construction bid documents and award of construction contract.
2 - 3	Equipment fabrication and delivery of structural components to site.
3 - 4	Delivery of remaining equipment and completion of construction including process tie in.
4 - 5	Equipment start up and source testing.

Figure 3.4.18 Schedule for installation of fabric filter on blending and packaging operations for particulate pollutant control.



MILESTONES

		ELAPSED TIME (WEEKS)
1	Date of submittal of final control plan to appropriate agency.	4
2	Date of award of control device contract.	12
3	Date of initiation of on-site construction or installation of emission control equipment.	31
4	Date by which on-site construction or installation of emission control equipment is completed.	51
5	Date by which final compliance is achieved.	53

ACTIVITIES

Designation	
A-C	Preliminary investigation
A-B	Source tests
C-D	Evaluate control alternatives
D-E	Commit funds for total program
E-F	Prepare preliminary control plan and compliance schedule for agency
F-G	Agency review and approval
G-1	Finalize plans and specifications
1-H	Procure control device bids
H-J	Evaluate control device bids
J-2	Award control device contract
2-K	Vendor prepares assembly drawings

Designation	
K-L	Review and approval of assembly drawings
L-M	Vendor prepares fabrication drawings
M-N	Fabricate control device
L-O	Prepare engineering drawings
O-P	Procure construction bids
P-Q	Evaluate construction bids
Q-3	Award construction contract
3-N	On-site construction
N-R	Install control device
R-4	Complete construction (system tie-in)
4-5	Startup, shakedown, preliminary source test

3.5 Agricultural Products

3.5.1 Grain Handling and Processing

Process Description - Grain handling and processing encompass a variety of operations from the initial receipt of the grain at either a country or terminal elevator to the delivery of such finished products as flour, livestock feed, soybean oil, and corn syrup. Primary operations in this industry include: (1) grain handling and transferring; (2) milling of dry corn, wet corn, soybeans, rice, durum and wheat; and (3) feed manufacturing.

Grain is handled and transferred at country and terminal elevators. Country elevators receive grain from farms by truck for future delivery to terminal elevators. At a typical terminal elevator, the grain is unloaded, cleaned, dried, stored, turned periodically, and eventually either shipped to another elevator or processed at an adjacent facility. Figure 3.5.1 illustrates the basic operations of a terminal elevator.

Milling of dry and wet corn, soybeans, rice, durum, and wheat involves several steps: (1) grain receiving; (2) cleaning and drying; (3) grinding or milling; (4) sifting, separating, and mixing; and (5) final load-out of the finished products and byproducts. Unloading and loading operations

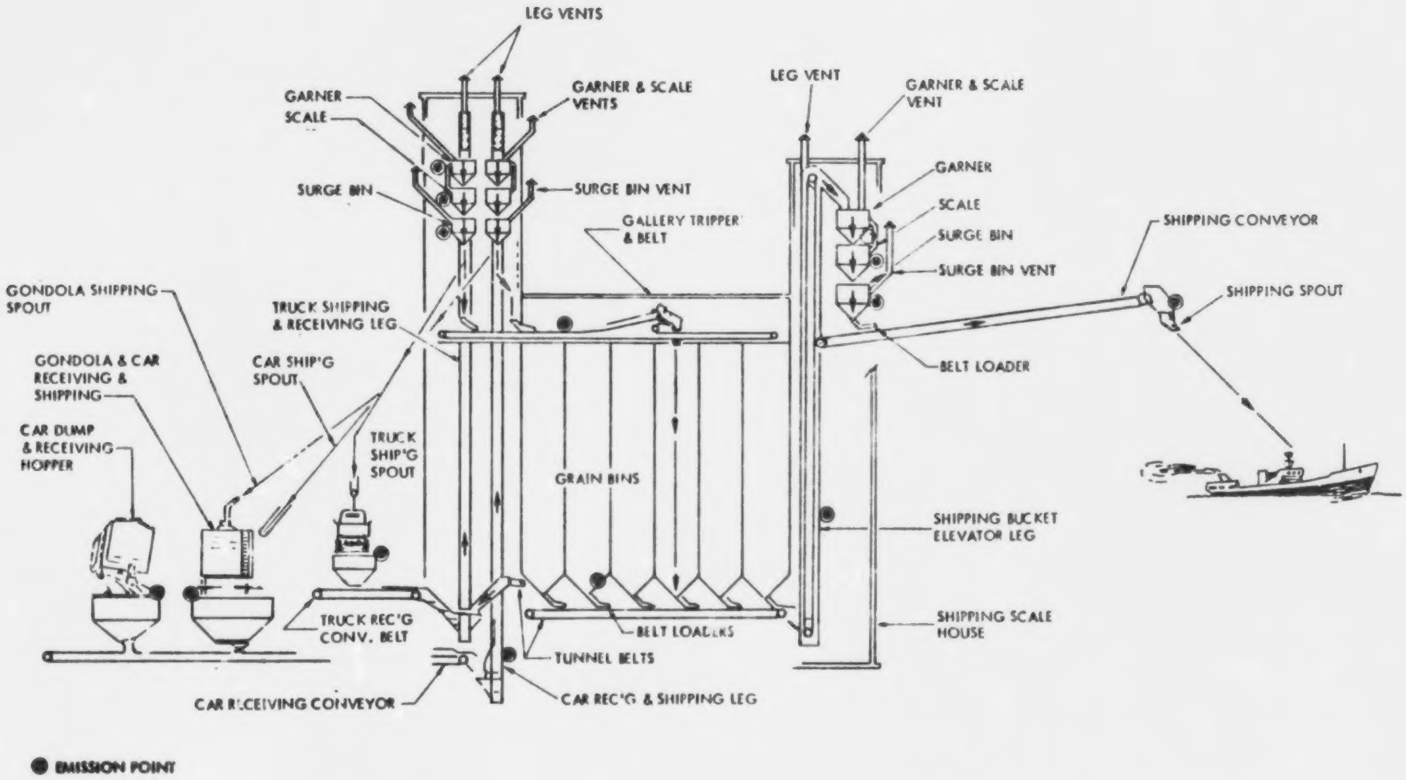

LEG VENTS
GARNER
SCALE
GARNER & SCALE VENTS
SURGE BIN
SURGE BIN VENT
GALLERY TRIPPER & BELT
LEG VENT
GARNER & SCALE VENT
GARNER
SCALE
SURGE BIN
SURGE BIN VENT
SHIPPING CONVEYOR
SHIPPING SPOUT
GONDOLA SHIPPING SPOUT
TRUCK SHIPPING & RECEIVING LEG
BELT LOADER
GONDOLA & CAR RECEIVING & SHIPPING
CAR SHIP'G SPOUT
CAR DUMP & RECEIVING HOPPER
TRUCK SHIP'G SPOUT
GRAIN BINS
SHIPPING BUCKET ELEVATOR LEG
TRUCK REC'G CONV. BELT
BELT LOADERS
SHIPPING SCALE HOUSE
TUNNEL BELTS
CAR RECEIVING CONVEYOR
CAR REC'G & SHIPPING LEG
● EMISSION POINT

Figure 3.5.1 Terminal elevator.

are similar to those of a terminal elevator. The by-products of the milling industries are frequently shipped to feed mills for further processing. Figures 3.5.2, 3.5.3, and 3.5.4 illustrate general operations for soybean processing, flour milling, and wet corn milling.

Processing of grains into mixed feed involves grinding the grain, mixing it with the other ingredients required by the formula, and then forming the feed into the desired shape and consistency. The basic forms of finished feed are mash, pellets, and crumbles.

Grinding and mixing are the two basic operations in each feed mill. Extrusion and cooling are additional operations in the manufacture of pellets. If pellets are broken into "crumbles" or "granules", the crumbling operation and screening follow the pelletizing operation. Figure 3.5.5 illustrates the general flow diagram for a typical feed mill.

Atmospheric Emissions - Particulate emissions are of primary concern in most grain industry operations. The emission rates are highly variable, depending upon such factors as cleanliness of grain, process design, and operating practices. Emissions from the various processes generally range between 2 and 8 pounds of particulate per ton of material handled or

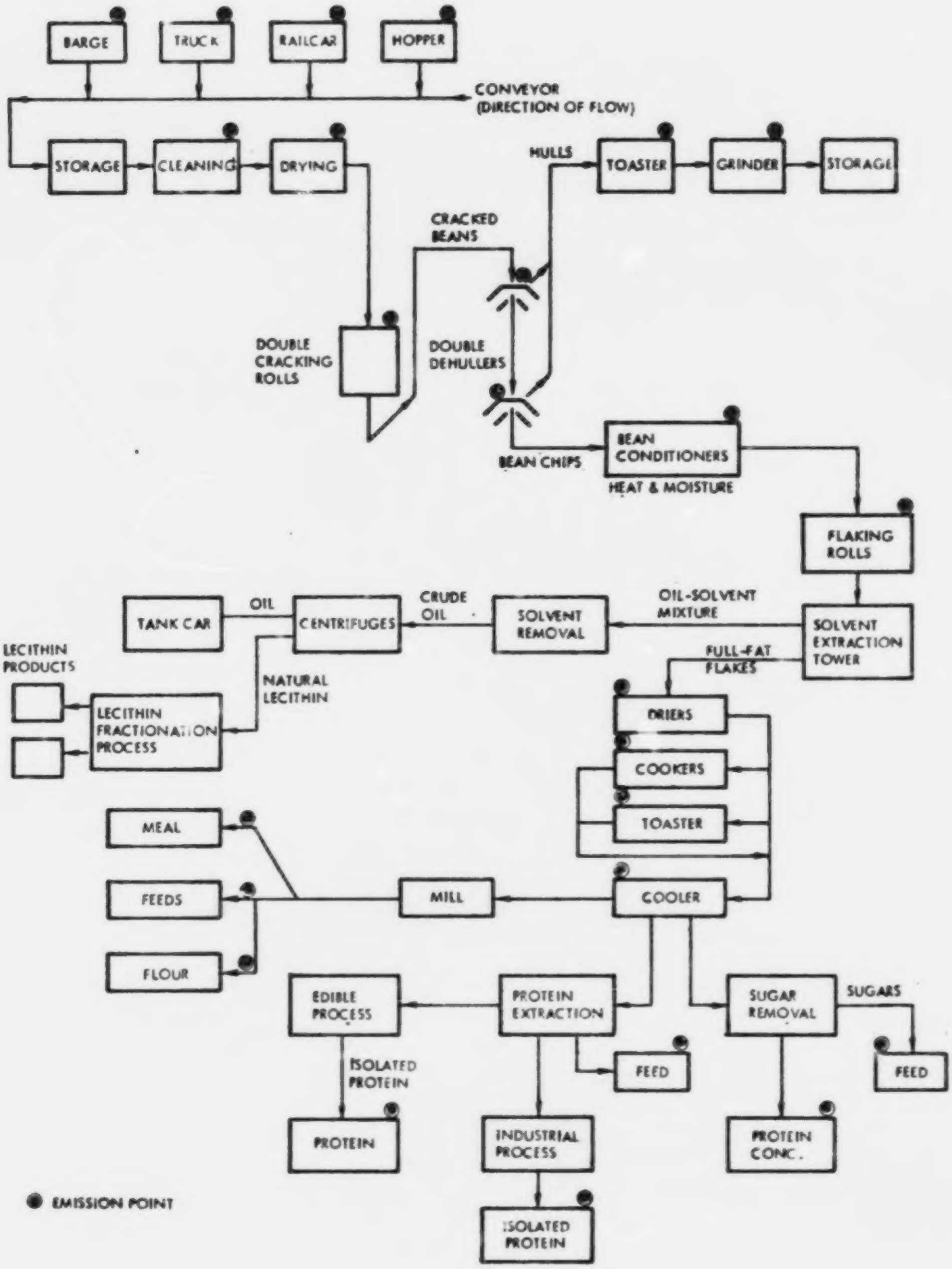

BARGE
TRUCK
RAILCAR
HOPPER
CONVEYOR (DIRECTION OF FLOW)
STORAGE
CLEANING
DRYING
HULLS
TOASTER
GRINDER
STORAGE
CRACKED BEANS
DOUBLE CRACKING ROLLS
DOUBLE DEHULLERS
BEAN CHIPS
BEAN CONDITIONERS
HEAT & MOISTURE
FLAKING ROLLS
TANK CAR
OIL
CENTRIFUGES
CRUDE OIL
SOLVENT REMOVAL
OIL-SOLVENT MIXTURE
SOLVENT EXTRACTION TOWER
LECITHIN PRODUCTS
NATURAL LECITHIN
LECITHIN FRACTIONATION PROCESS
FULL-FAT FLAKES
DRIERS
COOKERS
TOASTER
MEAL
FEEDS
FLOUR
MILL
COOLER
EDIBLE PROCESS
PROTEIN EXTRACTION
SUGAR REMOVAL
SUGARS
ISOLATED PROTEIN
FEED
FEED
PROTEIN
INDUSTRIAL PROCESS
PROTEIN CONC.
ISOLATED PROTEIN
EMISSION POINT

Figure 3.5.2 Soybean processing.

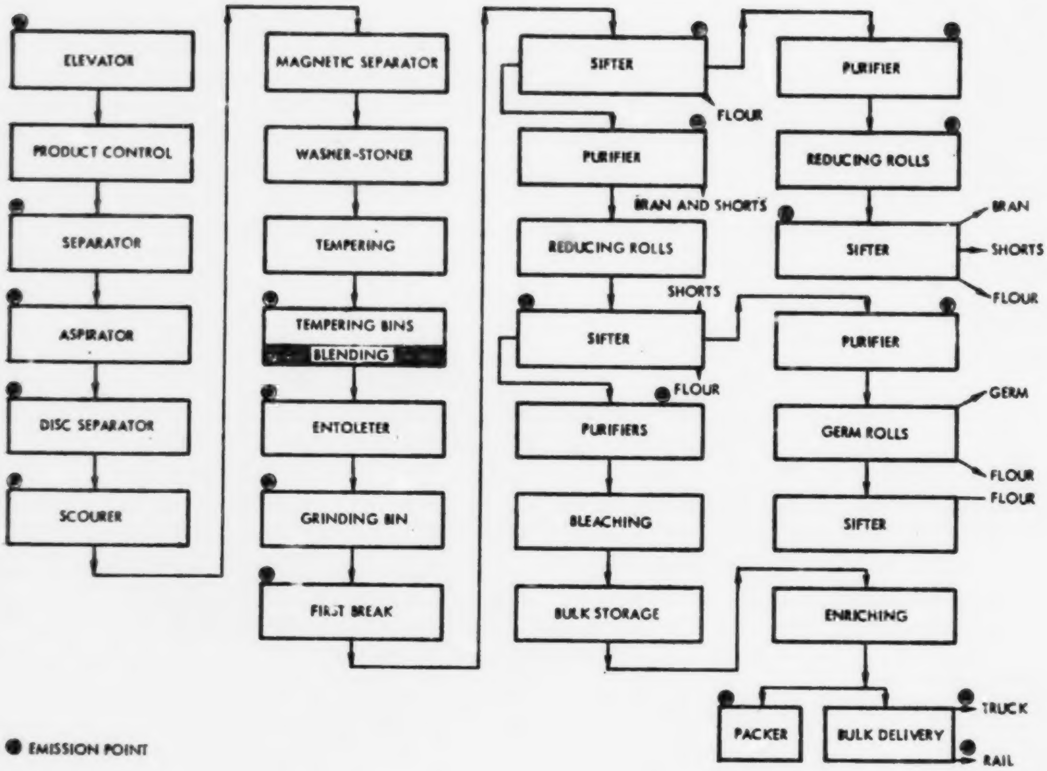

ELEVATOR
PRODUCT CONTROL
SEPARATOR
ASPIRATOR
DISC SEPARATOR
SCOURER
MAGNETIC SEPARATOR
WASHER-STONER
TEMPERING
TEMPERING BINS
BLENDING
ENTOLETER
GRINDING BIN
FIRST BREAK
SIFTER
FLOUR
PURIFIER
BRAN AND SHORTS
REDUCING ROLLS
SHORTS
SIFTER
FLOUR
PURIFIERS
BLEACHING
BULK STORAGE
PURIFIER
REDUCING ROLLS
SIFTER
BRAN
SHORTS
FLOUR
PURIFIER
GERM ROLLS
GERM
FLOUR
SIFTER
FLOUR
ENRICHING
PACKER
BULK DELIVERY
TRUCK
RAIL
● EMISSION POINT

Figure 3.5.3 Flour milling.

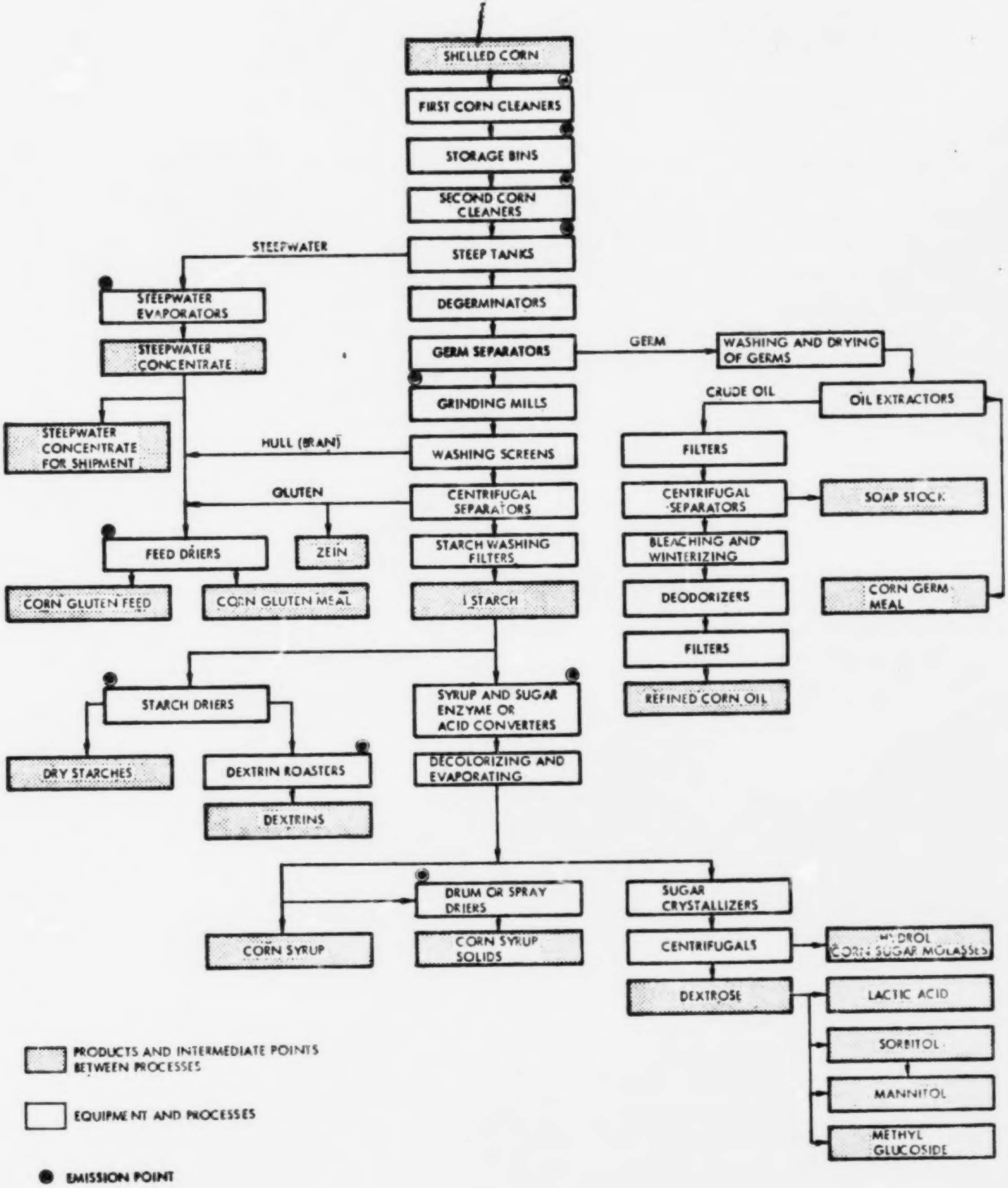

SHELLED CORN
FIRST CORN CLEANERS
STORAGE BINS
SECOND CORN CLEANERS
STEEPWATER
STEEP TANKS
STEEPWATER EVAPORATORS
DEGERMINATORS
STEEPWATER CONCENTRATE
GERM SEPARATORS
GERM
WASHING AND DRYING OF GERMS
GRINDING MILLS
CRUDE OIL
OIL EXTRACTORS
STEEPWATER CONCENTRATE FOR SHIPMENT
HULL (BRAN)
WASHING SCREENS
FILTERS
GLUTEN
CENTRIFUGAL SEPARATORS
CENTRIFUGAL SEPARATORS
SOAP STOCK
FEED DRIERS
ZEIN
STARCH WASHING FILTERS
BLEACHING AND WINTERIZING
CORN GLUTEN FEED
CORN GLUTEN MEAL
STARCH
DEODORIZERS
CORN GERM MEAL
FILTERS
STARCH DRIERS
SYRUP AND SUGAR ENZYME OR ACID CONVERTERS
REFINED CORN OIL
DRY STARCHES
DEXTRIN ROASTERS
DECOLORIZING AND EVAPORATING
DEXTRINS
DRUM OR SPRAY DRIERS
SUGAR CRYSTALLIZERS
CORN SYRUP
CORN SYRUP SOLIDS
CENTRIFUGALS
HYDROL CORN SUGAR MOLASSES
DEXTROSE
LACTIC ACID
SORBITOL
MANNITOL
METHYL GLUCOSIDE
PRODUCTS AND INTERMEDIATE POINTS BETWEEN PROCESSES
EQUIPMENT AND PROCESSES
EMISSION POINT

Figure 3.5.4 Wet corn milling.

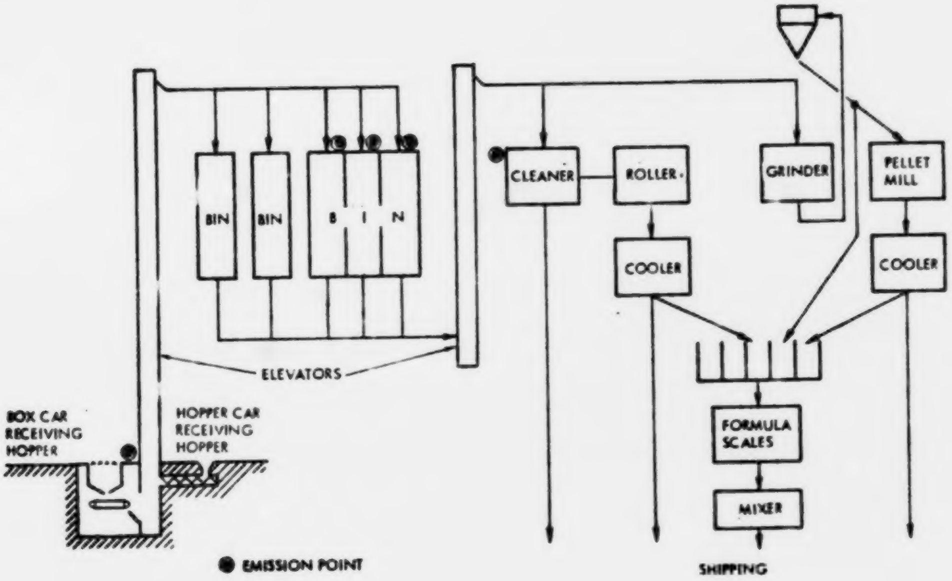

BIN
BIN
B I N
CLEANER
ROLLER
GRINDER
PELLET MILL
COOLER
COOLER
ELEVATORS
BOX CAR RECEIVING HOPPER
HOPPER CAR RECEIVING HOPPER
FORMULA SCALES
MIXER
SHIPPING
● EMISSION POINT

Figure 3.5.5 Feed manufacturing.

processed. Fugitive dust emissions can be a major problem in grain unloading or loading. Adequate enclosures and hooding systems must be used in conjunction with emission control devices.

Control Systems - Fabric filters and mechanical collectors (cyclones) are the most commonly used control devices. Fabric filters operate with efficiencies greater than 99.9 percent, with no visible emissions. Air-to-cloth ratios generally range between 10 and 15 (CFM per ft^2 of filter area); the higher ratios are used for intermittent operations and in drier geographical areas. Fabric filters are not used on streams having high moisture content because of the tendency of the fabric to "blind".

Because of the relatively large size of the emitted particulates, mechanical collectors can operate with high collection efficiencies. For example, cyclones on pneumatic conveying systems can operate with efficiencies in excess of 99 percent. For most emission sources, however, mechanical collectors will allow a visible discharge even though collection efficiencies are relatively high.

Because of the large volumes of effluent and its high moisture content, and the seasonal nature of grain drying, grain driers are usually controlled with various types of relatively low-cost "screen systems". Wire mesh screens, usually of 24, 35, or 50 mesh, and occasionally 100 mesh, Dacron have been used. Velocities through the screen are generally a few hundred fpm. One of the more effective devices is a sliding-bar, self-cleaning screen system using 100 mesh Dacron. Drier emissions are vented through screens mounted on long vertical panels in a housing attached to the drier exhaust. The screens are cleaned by a vacuum head which traverses the screen surface. The vacuum stream, which is about 10 percent of the total drier discharge, is exhausted through a high-efficiency cyclone or recycled through the drier.

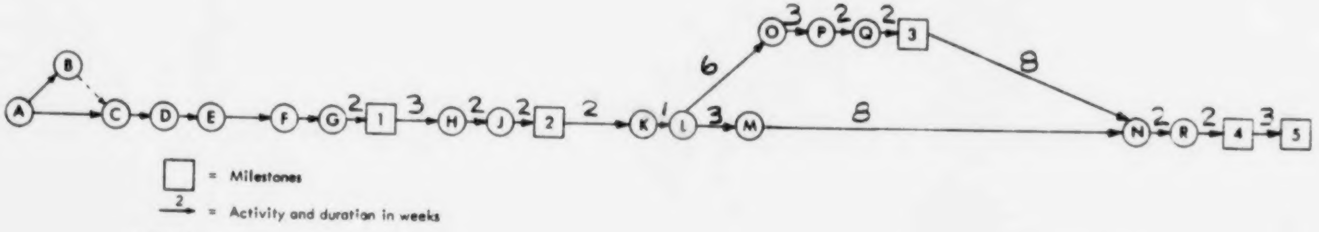
Compliance Schedules - Figures 3.5.6 and 3.5.7 illustrate expeditious schedules for installation of a baghouse or self-cleaning screen, and a high-energy cyclone, respectively.

Sources of Additional Information

Source	Type of Information*
1. Engineering and Cost Study of Emission Control in the Grain and Feed Industry. Prepared by Midwest Research Institute and PEDCo-Environmental under Contract No. 68-02-0213. Environmental Protection Agency, Research Triangle Park, North Carolina	P, E, C
2. Air Pollution Engineering Manual PHS Publication No. 999-AP-40	P, E, C

* P = Process description
E = Emission rates
C = Control devices

Figure 3.5.6 Schedule for installation of baghouse or self-cleaning screen filter on grain handling and processing sources for particulate pollutant control.



MILESTONES

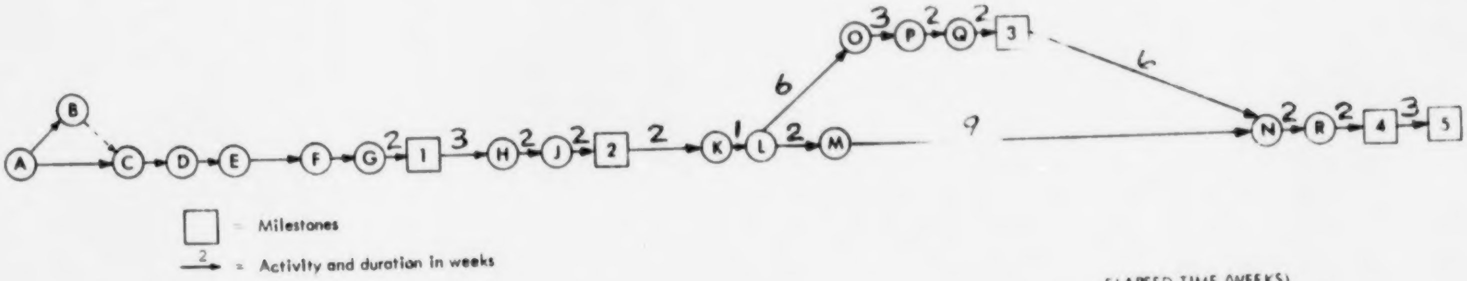
		ELAPSED TIME (WEEKS)
1	Date of submittal of final control plan to appropriate agency.	2
2	Date of award of control device contract.	9
3	Date of initiation of on-site construction or installation of emission control equipment.	25
4	Date by which on-site construction or installation of emission control equipment is completed.	37
5	Date by which final compliance is achieved.	40

ACTIVITIES

Designation	
A-C	Preliminary investigation
A-B	Source tests
C-D	Evaluate control alternatives
D-E	Commit funds for total program
E-F	Prepare preliminary control plan and compliance schedule for agency
F-G	Agency review and approval
G-1	Finalize plans and specifications
1-H	Procure control device bids
H-J	Evaluate control device bids
J-2	Award control device contract
2-K	Vendor prepares assembly drawings

Designation	
K-L	Review and approval of assembly drawings
L-M	Vendor prepares fabrication drawings
M-N	Fabricate control device
L-O	Prepare engineering drawings
O-P	Procure construction bids
P-Q	Evaluate construction bids
Q-3	Award construction contract
3-N	On-site construction
N-R	Install control device
R-4	Complete construction (system tie-in)
4-5	Startup, shakedown, preliminary source test

Figure 3.5.7 Schedule for installation of high-energy cyclone on grain handling and processing sources for particulate pollutant control.



MILESTONES

		ELAPSED TIME (WEEKS)
1	Date of submittal of final control plan to appropriate agency.	2
2	Date of award of control device contract.	9
3	Date of initiation of on-site construction or installation of emission control equipment	25
4	Date by which on-site construction or installation of emission control equipment is completed.	35
5	Date by which final compliance is achieved.	38

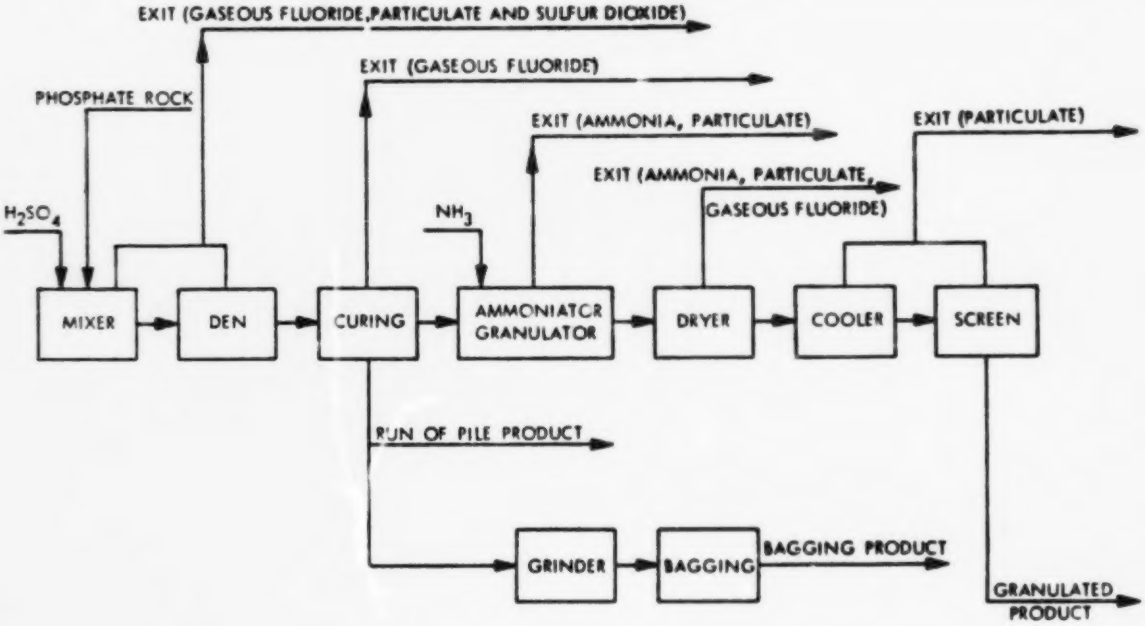
ACTIVITIES

Designation	
A-C	Preliminary investigation
A-B	Source tests
C-D	Evaluate control alternatives
D-E	Commit funds for total program
E-F	Prepare preliminary control plan and compliance schedule for agency
F-G	Agency review and approval
G-1	Finalize plans and specifications
1-H	Procure control device bids
H-J	Evaluate control device bids
J-2	Award control device contract
2-K	Vendor prepares assembly drawings

Designation	
K-L	Review and approval of assembly drawings
L-M	Vendor prepares fabrication drawings
M-N	Fabricate control device
L-O	Prepare engineering drawings
O-P	Procure construction bids
P-Q	Evaluate construction bids
Q-3	Award construction contract
3-N	On-site construction
N-R	Install control device
R-4	Complete construction (system tie-in)
4-5	Startup, shakedown, preliminary source test

3.5.2 Phosphate Fertilizer

Process Description - Among the commonly produced phosphate fertilizers are normal superphosphate, triple superphopshate, and ammonium phosphates. Normal superphosphate is produced by reacting sulfuric acid with phosphate rock. Sulfuric acid and phosphate rock are intimately mixed, dropped into a den, held for sufficient time to allow the slurry mixture to set, and then stored to permit the acidulation to go to completion. Following the curing period, the solid fertilizer is either sold as run-of-pile (ROP) product or processed further through (1) grinding and bagging or (2) granulating and reacting with ammonia to produce a granular mixed fertilizer. Figure 3.5.8 is a simplified flow diagram of a normal superphosphate plant.



EXIT (GASEOUS FLUORIDE,PARTICULATE AND SULFUR DIOXIDE)
EXIT (GASEOUS FLUORIDE)
PHOSPHATE ROCK
EXIT (AMMONIA, PARTICULATE)
EXIT (PARTICULATE)
EXIT (AMMONIA, PARTICULATE, GASEOUS FLUORIDE)
H_2SO_4
NH_3
MIXER
DEN
CURING
AMMONIATOR GRANULATOR
DRYER
COOLER
SCREEN
RUN OF PILE PRODUCT
GRINDER
BAGGING
BAGGING PRODUCT
GRANULATED PRODUCT

Figure 3.5.8 Normal superphosphate plant.

Triple superphosphate, which is also referred to as double or concentrated superphosphate, is produced through the reaction of phosphate rock and phosphoric acid. Unlike normal superphosphate, the production of triple superphosphate is usually a continuous operation in large plants located near phosphate rock deposits.

Two major processes are used in the production of triple superphosphate. The first uses a mixing cone to achieve initimate contact between the acid and rock. The resulting mix falls on a conveyor belt which moves the material to the curing building. After curing for 30 to 60 days, the product is sold as run-of-pile or is granulated in separate equipment.

The second process produces granulated fertilizer directly. Acid and phosphate rock are placed in mixing tanks, fed through a plunger for intimate mixing and release of some of the effluent gases, and then dried in a rotary dryer. The product is a directly granulated material which is rather hard and dense, and normally not amenable to ammoniating. Figure 3.5.9 is a simplified flow diagram for a triple superphosphate plant.

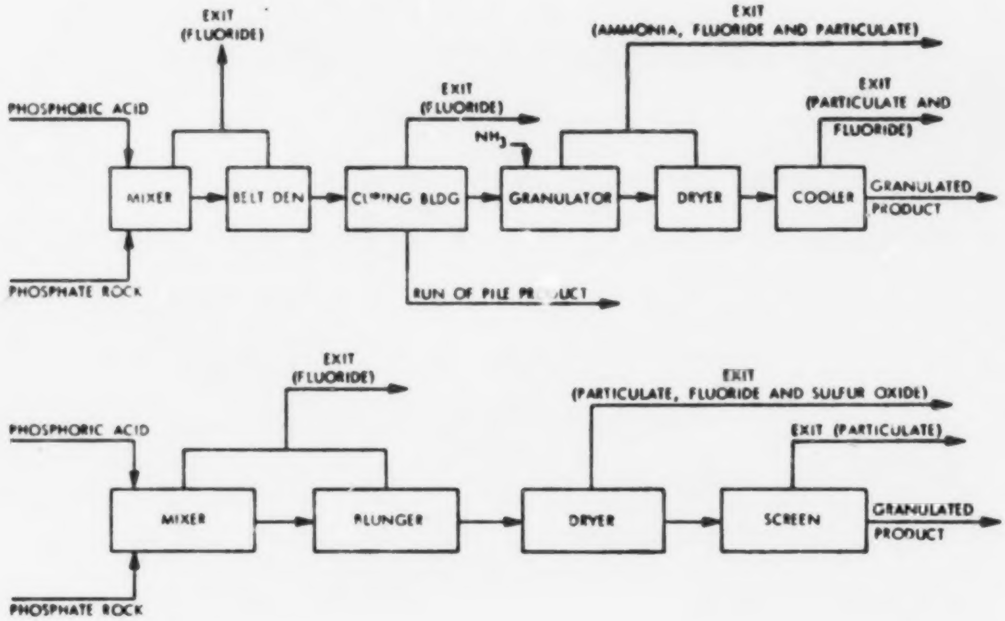

EXIT
(FLUORIDE)
PHOSPHORIC ACID
MIXER
BELT DEN
EXIT
(FLUORIDE)
CURING BLDG
NH3
GRANULATOR
EXIT
(AMMONIA, FLUORIDE AND PARTICULATE)
DRYER
EXIT
(PARTICULATE AND
FLUORIDE)
COOLER
GRANULATED
PRODUCT
PHOSPHATE ROCK
RUN OF PILE PRODUCT
EXIT
(FLUORIDE)
PHOSPHORIC ACID
MIXER
PLUNGER
EXIT
(PARTICULATE, FLUORIDE AND SULFUR OXIDE)
DRYER
EXIT (PARTICULATE)
SCREEN
GRANULATED
PRODUCT
PHOSPHATE ROCK

Figure 3.5.9 Triple superphosphate plant.

Diammonium phosphate is produced from phosphoric acid, ammonia, and sulfuric acid. Ammonia and sulfuric and phosphoric acids are mixed in a reactor and the product of the reactor is pumped as a slurry to a rotary ammoniator. Ammonia is sparged underneath the mixing bed in the ammoniator to achieve the desired ammonia level. While the equipment is rotating, agglomeration takes place and the ammoniation is completed. The diammonium phosphate granules are discharged into a rotary dryer, and then through a screening station, a rotary cooler, and finally conveyed to storage. A simplified flow diagram for a diammonium phosphate plant is shown in Figure 3.5.10.

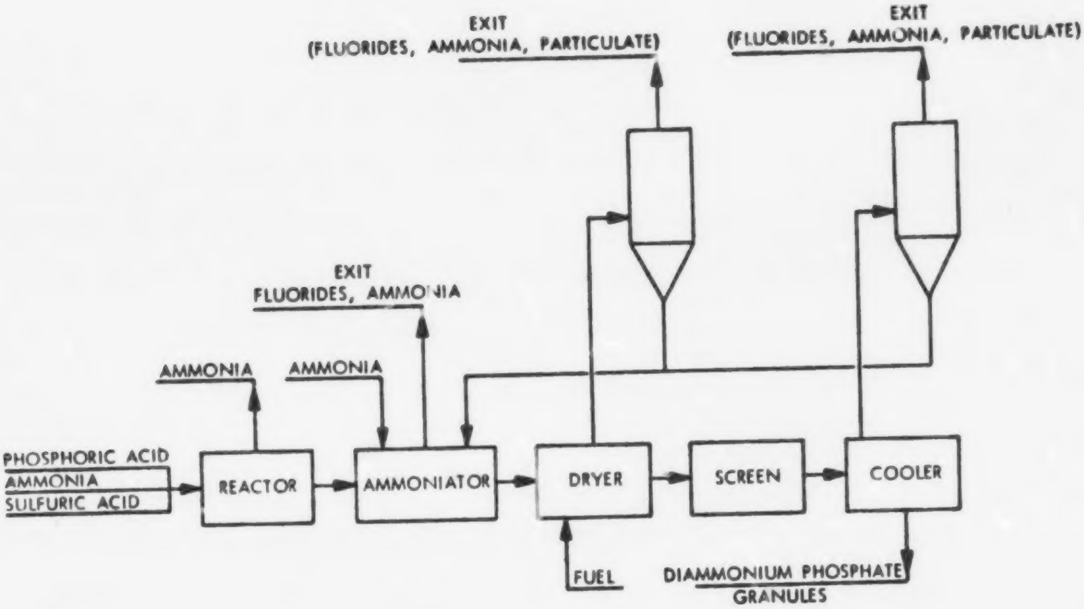

EXIT
(FLUORIDES, AMMONIA, PARTICULATE)
EXIT
(FLUORIDES, AMMONIA, PARTICULATE)
EXIT
FLUORIDES, AMMONIA
AMMONIA
AMMONIA
PHOSPHORIC ACID
AMMONIA
SULFURIC ACID
REACTOR
AMMONIATOR
DRYER
SCREEN
COOLER
FUEL
DIAMMONIUM PHOSPHATE
GRANULES

Figure 3.5.10 Diammonium phosphate plant.

Atmospheric Emission - The gases released from the acidulation of phosphate rock in normal superphosphate production contain silicon tetrafluoride, carbon dioxide, steam and sulfur dioxides. From 20 to 30 percent of the fluorine in the phosphate rock is evolved during the acidulation and curing operations. Vent gases from the granulator-ammoniator may contain ammonia, silicon tetrafluoride, hydrofluoric acid, ammonium chloride, and fertilizer dust. Emissions from the final drying of granulated product include gaseous and particulate fluorides, ammonia, and fertilizer dust.

In triple superphosphate plants, exit gases from plants producing nongranular products will contain considerable quantities of silicon tetrafluoride, some hydrogen fluoride, and small amounts of particulates. Fluorides are also emitted from the curing buildings. The emissions from run-of-pile granulated superphosphate are mostly dust and fumes, especially from the dryer and cooler.

The major pollutants from diammonium phosphate production are fluorides, particulates, and ammonia. Vent gases from the ammoniator tanks are the major source of ammonia emissions.

Control Systems - Spray towers, grid packed towers, and high velocity jet scrubbers are used to control fluoride and particulate emissions. Current practice is to send gases with either copious quantities of water or with dilute fluosilicic acid.

In triple superphosphate production, wet scrubbers are the primary method for controlling emissions of gaseous fluorides and particulate emissions. Packed towers, venturi scrubbers, wet-pad and impingement scrubbers have been used.

Control of emissions from fertilizer granulation involves collection of dry dust from rotary dryers, rotary coolers, and gas and dust from liquid-solid reactor units. Various high efficiency cyclones have been used for removal of dust in exit gases, followed by a wet scrubber to further reduce the dust content and to remove the acid constituents.

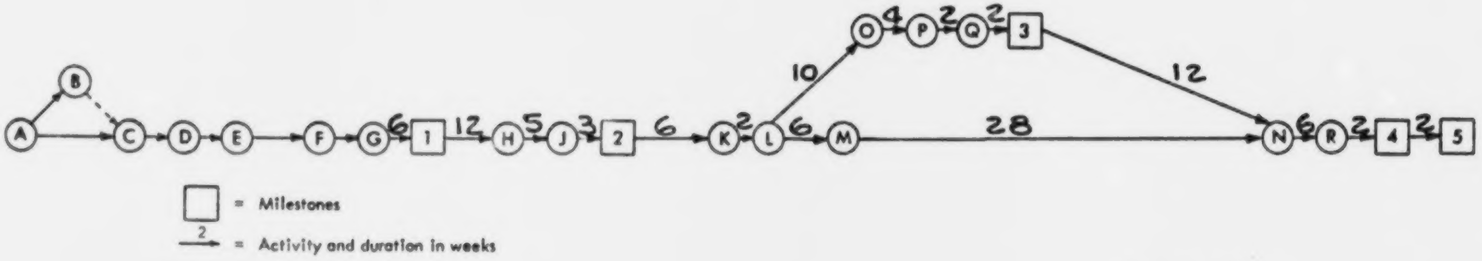
Compliance Schedules - Figure 3.5.11 illustrates an expeditious schedule for installation of a wet scrubber.

Sources of Additional Information

Source	Type of Information*
1. Handbook of Emissions and Control Practices for Stationary Particulate Pollution Sources NTIS No. 203-522	P, E, C

* P = Process description
E = Emission rates
C = Control devices

Figure 3.5.11 Schedule for installation of a wet scrubber on phosphate fertilizer operation for particulate and gaseous fluoride emissions control.



MILESTONES

		ELAPSED TIME (WEEKS)
1	Date of submittal of final control plan to appropriate agency.	6
2	Date of award of control device contract.	26
3	Date of initiation of on-site construction or installation of emission control equipment.	52
4	Date by which on-site construction or installation of emission control equipment is completed.	74
5	Date by which final compliance is achieved.	76

ACTIVITIES

Designation	
A-C	Preliminary investigation
A-B	Source tests
C-D	Evaluate control alternatives
D-E	Commit funds for total program
E-F	Prepare preliminary control plan and compliance schedule for agency
F-G	Agency review and approval
G-1	Finalize plans and specifications
1-H	Procure control device bids
H-J	Evaluate control device bids
J-2	Award control device contract
2-K	Vendor prepares assembly drawings

Designation	
K-L	Review and approval of assembly drawings
L-M	Vendor prepares fabrication drawings
M-N	Fabricate control device
L-O	Prepare engineering drawings
O-P	Procure construction bids
P-Q	Evaluate construction bids
Q-3	Award construction contract
3-N	On-site construction
N-R	Install control device
R-4	Complete construction (system tie-in)
4-5	Startup, shakedown, preliminary source test

3.6 Primary Metallurgical Processes

3.6.1 Metallurgical Coke

Process Description - Coke, an essential component in the manufacture of iron and steel, is the residue from the destructive distillation of coal. By-product coking, which is by far the most common process in the U.S., is a batch process involving batteries of 50 ovens or more. These slot coke ovens, in which coal is heated in the absence of air, are narrow refractory channels. Gas-fired flues between adjoining ovens keep the ovens at coking temperature.

Initially coal is blended to give uniform coking characteristics, then pulverized in hammermills and transferred to a storage silo above the battery of ovens. A weighed portion of coal is then discharged into a larry car, which is a wide-gauge vehicle fitted with coal hoppers. The coal is transferred from the hoppers into three to six opened coal-charging ports above an empty oven. The oven-charging ports are then closed for the duration of the 15 to 40 hour coking cycle.

As the charged coal is heated, the ovens emit a wide range of organic compounds, which are collected in standpipes or exhaust flues. These gases are sent to a by-product recovery section for separation and recovery of such by-products as tar, light aromatic compounds, ammonia liquor, and coke oven fuel gas.

Upon completion of the coking cycle, both end oven doors are opened and the incandescent coke is forced into a hot-coke car at one end of the oven by a large pusher ram at the opposite end. The hot-coke car, or quenching car, moves the coke to a quenching tower, a chimney-like structure in which the coke is deluged with water. The damp, quenched coke is then deposited in a sloping wharf, in which it drains and cools to a reasonably uniform moisture content and temperature. Figure 3.6.1 illustrates the overall coking process.

Atmospheric Emissions - The primary pollutants from coke manufacture are coal and coke dust, sulfur oxides, light hydrocarbons and aromatics, carbon monoxide, nitrogen oxides, and reduced sulfur compounds. Emissions can occur during coal handling, charging, pushing, and quenching. The emission sources of primary concern are charging, pushing and quenching, and combustion of the coke-oven gas.

Major emissions occur at the point of charging the coal to the oven, since the rapid heating of the coal causes volatilization of gases from the coal mass. These gases escape to the atmosphere through the charging ports unless controlled. Emissions also occur in the early stages of coking because of leaks at the charging ports and around the sealed end doors.

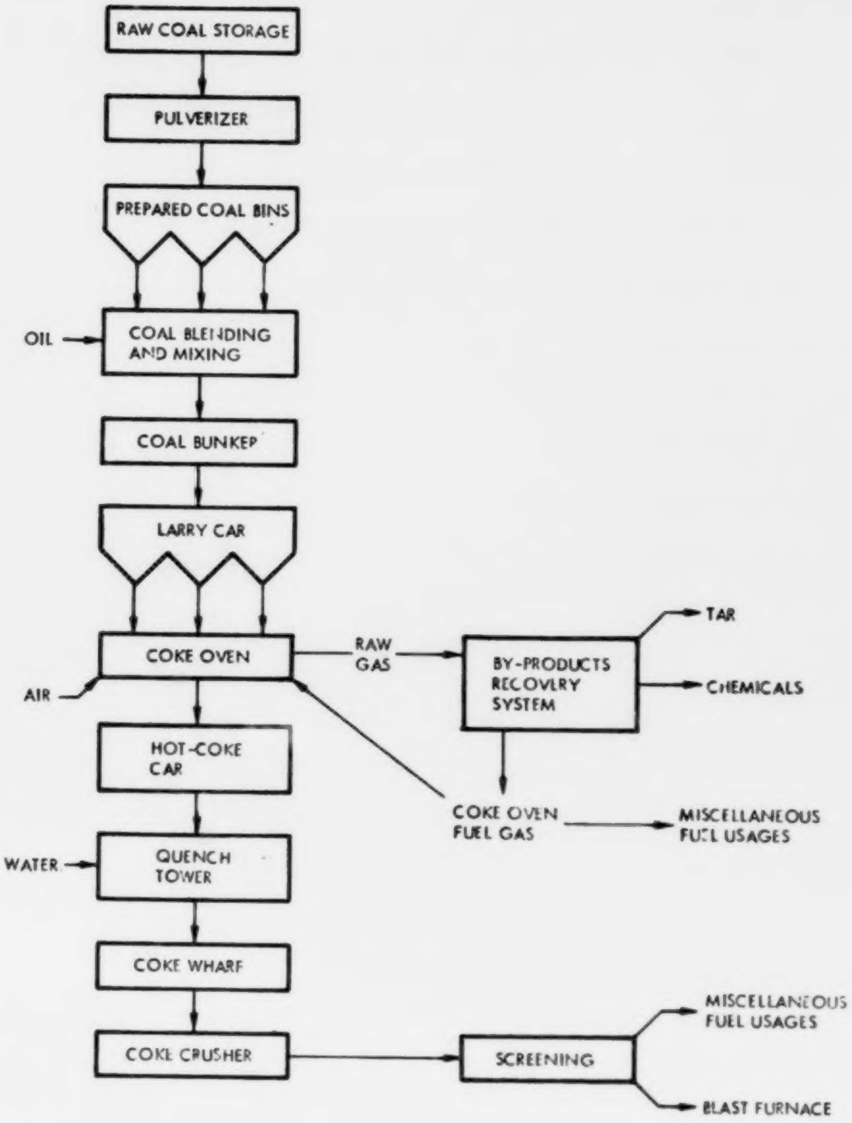

RAW COAL STORAGE
PULVERIZER
PREPARED COAL BINS
OIL
COAL BLENDING AND MIXING
COAL BUNKER
LARRY CAR
COKE OVEN
AIR
RAW GAS
BY-PRODUCTS RECOVERY SYSTEM
TAR
CHEMICALS
HOT-COKE CAR
COKE OVEN FUEL GAS
MISCELLANEOUS FUEL USAGES
WATER
QUENCH TOWER
COKE WHARF
COKE CRUSHER
SCREENING
MISCELLANEOUS FUEL USAGES
BLAST FURNACE

Figure 3.6.1 Metallurgical coke manufacturing

Coke-oven gas recovered in the by-product recovery system typically contains 3.5 to 4.5 grains per SCF of hydrogen sulfide. The coke-oven gas used for fuel in heating or underfiring the coke ovens and for other combustion operations results in sulfur oxides emissions unless the hydrogen sulfide has been removed.

Emissions resulting from discharge of the coke from the ovens consist of smoke from any incompletely coked coal and dust released as the coke is pushed into the hot-coke car.

Quenching of the hot coke results in a fine coke breeze formed during the pushing of the hot-coke car and as water is flash-evaporated within the coke itself. In addition, contaminated water, which is often used for quenching, can cause emissions of ammonia and phenol vapors.

Control Systems - A procedure commonly used to reduce emissions during coal charging is termed "charging on the main". A steam ejector in the ascension pipe produces a draft in the oven during the charging period which casues the gases to be pulled into the gas collector main. Although it has undergone some improvements, this technique is generally considered to be ineffective. The two most feasible improvements are charging on the main with closed coal ports and pipeline charging. Charging on the main with closed coal ports can be readily incorporated into an existing plant. Features of this system include sequencing of coal charging from the larry car with charging port lids off only during charging, maintenance of a steady negative pressure in the oven, and continual draw-off of evolved gases. Pipeline charging involves preheating coal to drive off moisture and transporting it by pipeline. Although a 40 to 50 percent increase in oven capacity can be realized with this method, it is considerably more expensive, requiring far more extensive equipment changes than charging on the main with closed coal ports. Furthermore, the capacity of the by-product recovery system must be increased to utilize the increase in oven capacity.

Several systems have been considered for control of emissions resulting from the discharge of newly produced coke. One system recently put in operation consists of an enclosed quench car which is attached to a second car that carries the wet scrubber unit. During the pushing operation, emissions are collected in the hood and withdrawn through the coupled duct work between the cars to the wet scrubber unit.

For removal of H_2S from coke oven gas, the vacuum carbonate process is the most widely accepted method applied on a large scale at present. Hydrogen sulfide is absorbed by a sodium carbonate stream and then released in a concentrated H_2S stream by steam stripping. By this method the H_2S level in the gas stream can be reduced by about 93 percent. A sulfur-recovery plant is normally used in conjunction with the vacuum carbonate process to convert the recovered H_2S into elemental sulfur. Certain newer processes, notably the Stretford and Takehax processes, can remove 99% or more H_2S but provisions must be made to handle the liquid effluent.

Compliance Schedules - Figures 3.6.2 and 3.6.3 illustrate reasonable schedules for installation of charging on the main with closed coal ports and pipeline charging systems for existing coke oven batteries. Differences in existing equipment may alter certain parts of the schedule.

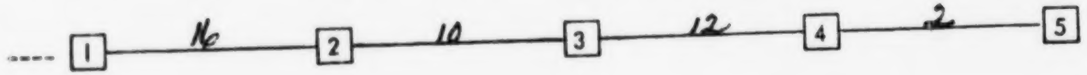
Figure 3.6.4 represents an estimated schedule for installation of a pushing hood system for emissions control during discharging of newly produced coke from existing coke oven batteries. Since only one pushing hood system is in operation in the U.S., and the delay in obtaining railroad cars required for this control system, this schedule must be considered a rough approximation.

Sources of Additional Information

Source	Type of Information*
(1) Evaluation of Process Alternatives to Improve Control of Air Pollution from Production of Coke NTIS: PB-189-266	P, E, C
(2) Kirk-Othmer. "Encyclopedia of Chemical Technology." A. Staden (ed.), Interscience Publ., New York, New York, 1969. Vol. 19, p. 383	C
(3) Control Techniques for Sulfur Oxide Air Pollutants, 2nd Edition Environmental Protection Agency	E, C

* P = Process description
E = Emission rates
C = Control devices

Figure 3.6.2 Schedule for installation of coal charging on the main with closed coal ports for an existing battery.

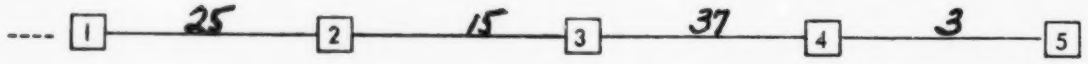


MILESTONES		ELAPSED TIME (WEEKS)
1	Date of submittal of final control plan to appropriate agency.	0
2	Date of award of control device contract.	16
3	Date of initiation of on-site construction or installation of emission control equipment.	26
4	Date by which on-site construction of emission control equipment is completed.	38
5	Date by which final compliance is achieved.	40

ACTIVITIES

DESIGNATIONS	
1 - 2	Preparation of detailed engineering and fabrication drawings, equipment specifications, construction bid documents and award of construction contract.
2 - 3	Equipment fabrication and delivery of structural components to site.
3 - 4	Delivery of remaining equipment and completion of construction including process tie in.
4 - 5	Equipment start up and source testing.

Figure 3.6.3 Schedule for installation of pipeline charging system for an existing battery.

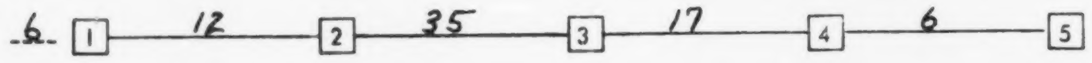


MILESTONES		ELAPSED TIME (WEEKS)
1	Date of submittal of final control plan to appropriate agency.	0
2	Date of award of control device contract.	25
3	Date of initiation of on-site construction or installation of emission control equipment.	40
4	Date by which on-site construction of emission control equipment is completed.	77
5	Date by which final compliance is achieved.	80

ACTIVITIES

DESIGNATIONS	
1 - 2	Preparation of detailed engineering and fabrication drawings, equipment specifications, construction bid documents and award of construction contract.
2 - 3	Equipment fabrication and delivery of structural components to site.
3 - 4	Delivery of remaining equipment and completion of construction including process tie in.
4 - 5	Equipment start up and source testing.

Figure 3.6.4 Schedule for installation of a hooded grind car system for control of particulate emissions during pushing and quenching operations.

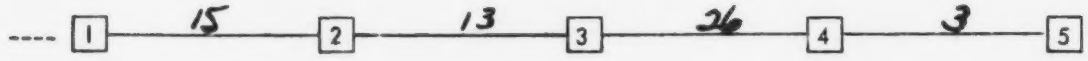


MILESTONES		ELAPSED TIME (WEEKS)
1	Date of submittal of final control plan to appropriate agency.	6
2	Date of award of control device contract.	18
3	Date of initiation of on-site construction or installation of emission control equipment.	53
4	Date by which on-site construction of emission control equipment is completed.	70
5	Date by which final compliance is achieved.	76

ACTIVITIES

DESIGNATIONS	
1 - 2	Preparation of detailed engineering and fabrication drawings, equipment specifications, construction bid documents and award of construction contract.
2 - 3	Equipment fabrication and delivery of structural components to site.
3 - 4	Delivery of remaining equipment and completion of construction including process tie in.
4 - 5	Equipment start up and source testing.

Figure 3.6.5 Schedule for installation of vacuum carbonate scrubbing process.

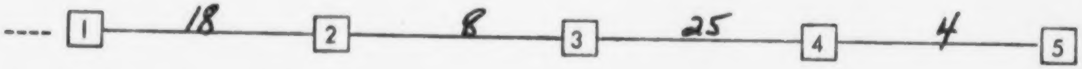


MILESTONES		ELAPSED TIME (WEEKS)
1	Date of submittal of final control plan to appropriate agency.	0
2	Date of award of control device contract.	15
3	Date of initiation of on-site construction or installation of emission control equipment.	28
4	Date by which on-site construction of emission control equipment is completed.	54
5	Date by which final compliance is achieved.	57

ACTIVITIES

DESIGNATIONS	
1 - 2	Preparation of detailed engineering and fabrication drawings, equipment specifications, construction bid documents and award of construction contract.
2 - 3	Equipment fabrication and delivery of structural components to site.
3 - 4	Delivery of remaining equipment and completion of construction including process tie in.
4 - 5	Equipment start up and source testing.

Figure 3.6.6. Schedule for installation of a sulfur-recovery unit (Claus plant)



MILESTONES		ELAPSED TIME (WEEKS)
1	Date of submittal of final control plan to appropriate agency.	0
2	Date of award of control device contract.	18
3	Date of initiation of on-site construction or installation of emission control equipment.	26
4	Date by which on-site construction of emission control equipment is completed.	51
5	Date by which final compliance is achieved.	55

ACTIVITIES

DESIGNATIONS	
1 - 2	Preparation of detailed engineering and fabrication drawings, equipment specifications, construction bid documents and award of construction contract.
2 - 3	Equipment fabrication and delivery of structural components to site.
3 - 4	Delivery of remaining equipment and completion of construction including process tie in.
4 - 5	Equipment start up and source testing.

3.6.2 Iron and Steel

Process Description - Figure 3.6.7 illustrates the overall process flow at an integrated iron and steel mill. Iron ore in either pellet or sinter form is fed to the blast furnace, along with limestone and coke, where it is reduced to form pig iron. The pig iron is then refined to steel in open-hearth, electric arc, or basic oxygen furnaces. The molten steel from the furnaces is cooled and undergoes a variety of shaping and forming operations to produce billets, slabs, or rolls, which are then heat- and surface-treated.

Ancillary operations at an integrated steel mill include coke manufacture and sintering. Coke manufacture, resultant emissions, and control methods are described in Section 3.6.1. In the sintering operation, iron ore fines and recovered dust from various emission sources are mixed with coke fines and limestone, and fed to the sintering machine to form a fused mass suitable for use as feed to the blast furnace.

Atmospheric Emissions - Emissions from the blast furnace consist primarily of particulates and carbon monoxide; sulfur in the coke and ore is trapped in the slag and hence is not emitted. High-efficiency particulate collection devices are

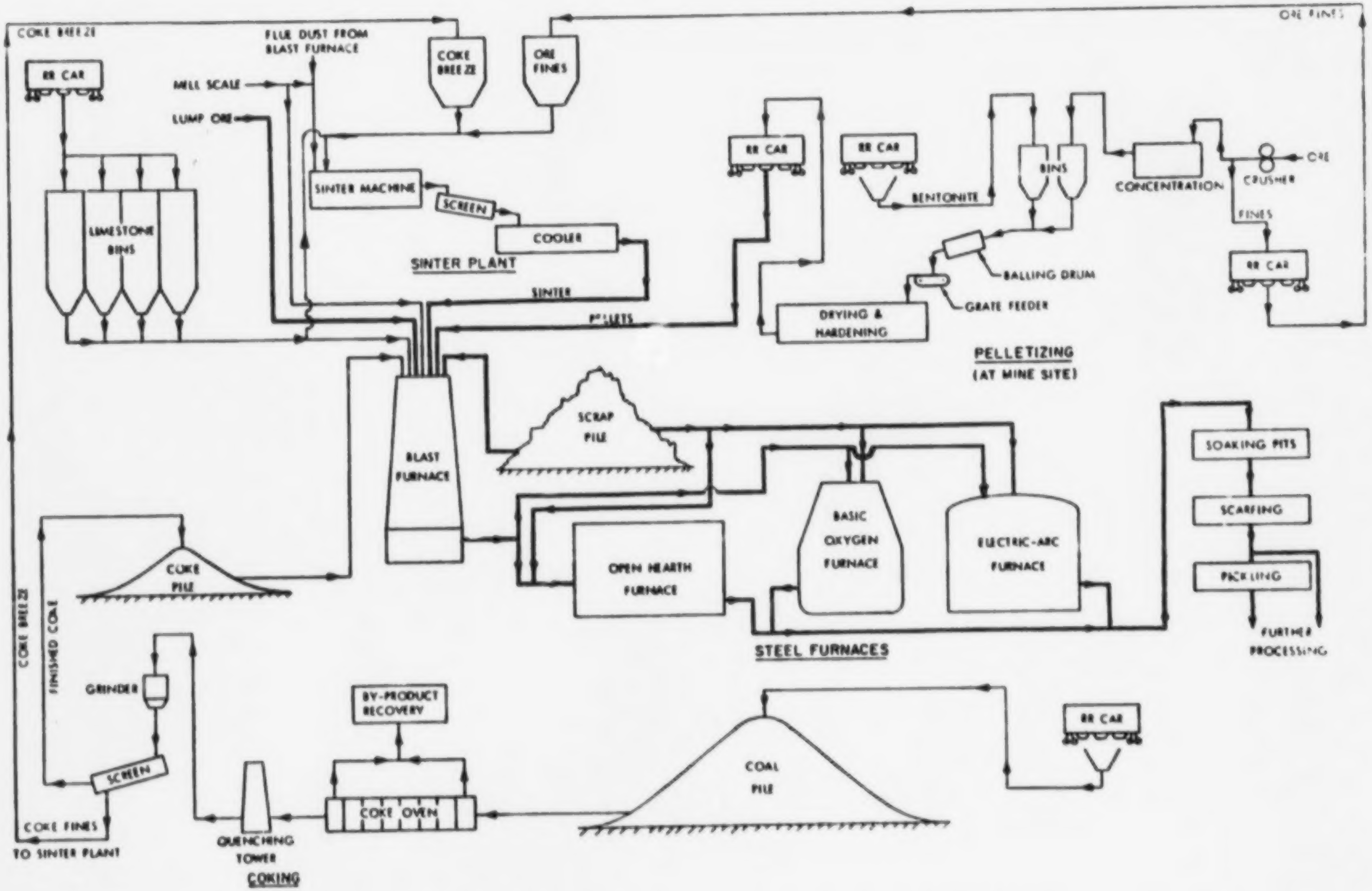

COKE BREEZE
RR CAR
LIMESTONE BINS
MILL SCALE
LUMP ORE
FLUE DUST FROM BLAST FURNACE
COKE BREEZE
ORE FINES
SINTER MACHINE
SCREEN
COOLER
SINTER PLANT
SINTER
PELLETS
RR CAR
RR CAR
BENTONITE
BINS
CONCENTRATION
CRUSHER
ORE
FINES
RR CAR
ORE FINES
BALLING DRUM
GRATE FEEDER
DRYING & HARDENING
PELLETIZING
(AT MINE SITE)
BLAST FURNACE
SCRAP PILE
OPEN HEARTH FURNACE
BASIC OXYGEN FURNACE
ELECTRIC-ARC FURNACE
STEEL FURNACES
SOAKING PITS
SCARFING
PICKLING
FURTHER PROCESSING
COKE PILE
FINISHED COKE
GRINDER
SCREEN
COKE FINES
TO SINTER PLANT
QUENCHING TOWER
COKING
BY-PRODUCT RECOVERY
COKE OVEN
COAL PILE
RR CAR

Figure 3.6.7 Integrated iron and steel facility.

not required as part of the process to prevent fouling of the checkerwork used for heat recovery. Between 2000 and 3000 pounds of CO per ton of pig iron are produced. Approximately 25 percent of this is sent to the blast furnace stoves to heat the incoming air. The remainder is used to fire boilers, coke ovens, and soaking pits.

Emissions from the steel making furnaces consist primarily of particulates and CO; to a limited extent, SO_2 may also be emitted from open-hearth furnaces due to the sulfur content of the fuel. Particulate emissions range from approximately 5 pounds per ton of steel produced for electric-arc furnaces without oxygen lancing to 60 pounds per ton for basic oxygen furnaces. Carbon monoxide emissions range from essentially nil for open-hearth furnaces to 150 pounds per ton for basic oxygen furnaces.

Sinter machines emit particulates and sulfur oxides; fluorides and other potentially hazardous materials may also be emitted depending upon the composition of the ore. The major sources of particulate emission are the windbox discharge gases and the discharge end of the sinter machine. Particulate emissions from each source are approximately 20 pounds per ton of sinter produced. Sulfur dioxide is emitted in the windbox discharge gases. Approximately 70 percent of the sulfur content of the feed mixture can be emitted as sulfur oxides.

Control Systems - Particulate emissions from steel furnaces can be controlled by electrostatic precipitators, fabric filters, and wet scrubbers. The trend has been toward high-energy venturi scrubbers because of the relative insensitivity of scrubber collection efficiency to variations in effluent stream conditions. Pressure drops of 60 to 100 inches water gauge are usually required, depending upon emission characteristics. Problems associated with application of electrostatic precipitators result from variations of effluent stream volume, moisture content, and temperature. The use of fabric filters has been essentially limited to electric-arc furnace installations.

Carbon monoxide in the effluent is usually burned in the hood system, except in a few basic oxygen furnace configurations, where it is recovered for use as a fuel. The gases are then cooled, usually by water sprays prior to the particulate control device.

Fabric filters, electrostatic precipitators, and wet scrubbers can be used to control sinter plant emissions. Special materials of construction are required for wet scrubber installations because of the sulfur content of the gas stream. In design of electrostatic precipitator installations, particular attention must be paid to the composition of the sinter; use of self-fluxing sinter impairs precipitator collection efficiency because of its higher resistivity. Fabric filter installations are designed with air to cloth ratios of approximately 2 to 3 cfm/ft^2 and predominantly use fiberglass bags.

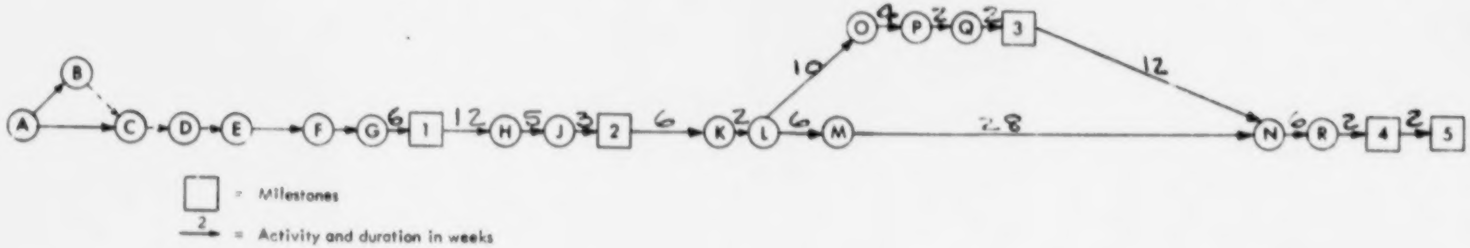
Compliance Schedules - Expeditious schedules for installation of a high-energy wet scrubber, an electrostatic precipitator, and a fabric filter on steel making furnaces or sinter plants are shown in Figures 3.6.8, 3.6.9, and 3.6.10, respectively.

Sources of Additional Information

Source	Type of Information*
1. The Making, Shaping and Treating of Steel, Ninth Edition U.S. Steel Corporation, Pittsburg, Pennsylvania	P
2. A Systems Analysis Study of the Integrated Iron and Steel Industry NTIS Publication No. PB 184-577	P, E, C
3. A Manual of Electrostatic Precipitator Technology NTIS Publication No. PB 196-381	C

* P = Process description
E = Emission rates
C = Control devices

Figure 3.6.8 Compliance schedule for installation of a high energy wet scrubber for particulate pollutant control.

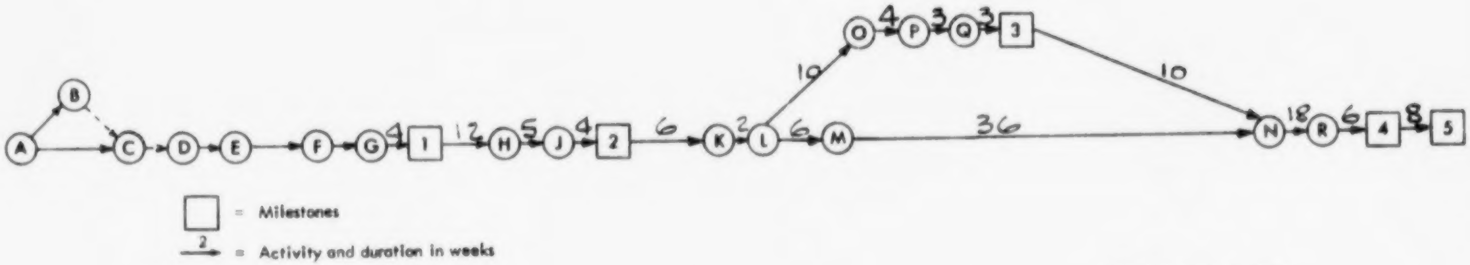


MILESTONES		ELAPSED TIME (WEEKS)
1	Date of submittal of final control plan to appropriate agency.	6
2	Date of award of control device contract.	26
3	Date of initiation of on-site construction or installation of emission control equipment.	52
4	Date by which on-site construction or installation of emission control equipment is completed.	74
5	Date by which final compliance is achieved.	76

ACTIVITIES

Designation		Designation	
A-C	Preliminary investigation	K-L	Review and approval of assembly drawings
A-B	Source tests	L-M	Vendor prepares fabrication drawings
C-D	Evaluate control alternatives	M-N	Fabricate control device
D-E	Commit funds for total program	L-O	Prepare engineering drawings
E-F	Prepare preliminary control plan and compliance schedule for agency	O-P	Procure construction bids
F-G	Agency review and approval	P-Q	Evaluate construction bids
G-1	Finalize plans and specifications	Q-3	Award construction contract
1-H	Procure control device bids	3-N	On-site construction
H-J	Evaluate control device bids	N-R	Install control device
J-2	Award control device contract	R-4	Complete construction (system tie-in)
2-K	Vendor prepares assembly drawings	4-5	Startup, shake-down, preliminary source test

Figure 3.6.9 Compliance schedule for installation of electrostatic precipitator for particulate pollutant control.



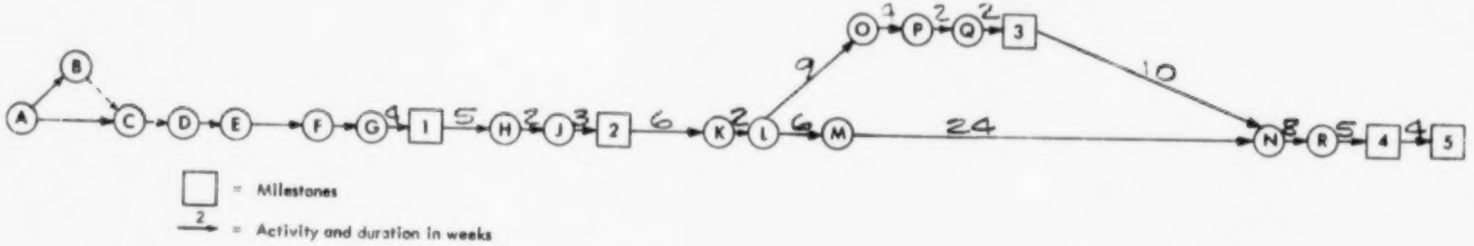
MILESTONES		ELAPSED TIME (WEEKS)
1	Date of submittal of final control plan to appropriate agency.	4
2	Date of award of control device contract.	25
3	Date of initiation of on-site construction or installation of emission control equipment.	63
4	Date by which on-site construction or installation of emission control equipment is completed.	97
5	Date by which final compliance is achieved.	107

ACTIVITIES

Designation	
A-C	Preliminary investigation
A-B	Source tests
C-D	Evaluate control alternatives
D-E	Commit funds for total program
E-F	Prepare preliminary control plan and compliance schedule for agency
F-G	Agency review and approval
G-1	Finalize plans and specifications
1-H	Procure control device bids
H-J	Evaluate control device bids
J-2	Award control device contract
2-K	Vendor prepares assembly drawings

Designation	
K-L	Review and approval of assembly drawings
L-M	Vendor prepares fabrication drawings
M-N	Fabricate control device
L-O	Prepare engineering drawings
O-P	Procure construction bids
P-Q	Evaluate construction bids
Q-3	Award construction contract
3-N	On-site construction
N-R	Install control device
R-4	Complete construction (system tie-in)
4-5	Startup, shakedown, preliminary source test

Figure 3.6.10 Compliance schedule for installation of a baghouse for particulate pollutant control.



MILESTONES

		ELAPSED TIME (WEEKS)
1	Date of submittal of final control plan to appropriate agency.	4
2	Date of award of control device contract.	14
3	Date of initiation of on-site construction or installation of emission control equipment.	39
4	Date by which on-site construction or installation of emission control equipment is completed.	65
5	Date by which final compliance is achieved.	69

ACTIVITIES

Designation		Designation	
A-C	Preliminary investigation	K-L	Review and approval of assembly drawings
A-B	Source tests	L-M	Vendor prepares fabrication drawings
C-D	Evaluate control alternatives	M-N	Fabricate control device
D-E	Commit funds for total program	L-O	Prepare engineering drawings
E-F	Prepare preliminary control plan and compliance schedule for agency	O-P	Procure construction bids
F-G	Agency review and approval	P-Q	Evaluate construction bids
G-1	Finalize plans and specifications	Q-3	Award construction contract
1-H	Procure control device bids	3-N	On-site construction
H-J	Evaluate control device bids	N-R	Install control device
J-2	Award control device contract	R-4	Complete construction (system tie-in)
2-K	Vendor prepares assembly drawings	4-5	Startup, shakedown, preliminary source test

3.6.3 Primary Aluminum

Process Description - Bauxite is the principal ore of aluminium. It consists of aluminium oxide and various impurities, such as iron oxide, aluminium silicate, and titanium dioxide. The production of alumina, which consists of separating it from the impurities in the bauxite ore, is accomplished entirely by chemical means. In the Sainto-Claire Deville process, the sodium aluminate is prepared by calcining the bauxite with sodium carbonate at 1100°C; the calcined material is then washed with alkali, yielding a sodium aluminate solution from which the alumina is precipitated by carbon dioxide. In the Bayer process, a more recent development, the separation is carried out entirely in the aqueous phase, taking advantage of the solubility equilibria of the alumina hydrates in a caustic soda solution.

Aluminium is produced electrolytically from alumina. The alumina is decomposed by a continuous current that flows through the electrolytic cell containing alumina dissolved in molten cryolite.

The electrolyte cell consists of a carbon-lined box containing a pad of molten aluminium that serves as a cathode, a carbon anode, and the alumina-cryolite bath. Usually 100 cells, commonly called pots, are connected in series to form a potline, each plant operating three to ten potlines.

In addition to fluorine, exhausts from the cells contain sulfur dioxide from the sulfur impurities in the anodes, tarry hydrocarbons, alumina and carbon particles, and oxides of carbon.

Other atmospheric emissions in aluminum reduction plants are caused by certain peripheral operations. Among these are the anode and paste manufacturing, which emit high-molecular-weight hydrocarbons and small carbon particles. The molten metal purification, alloying, and casting operations cause further emissions, mainly chlorides of aluminum and small amounts of hydrogen chloride and chlorine. A third peripheral operation related to the manufacture of anode and paste is the production of calcined petroleum coke. This operation involves heating the material to drive off moisture and volatiles, and transforming the carbon from an insulating to a conducting carbon.

Control Systems - As noted above, the principal potential pollutants in the electrolytic cell effluent are (1) particulate solids, including solid fluorides and alumina, (2) gaseous hydrogen fluoride, and (3) condensed hydrocarbon C (from Soderberg cells).

Because of specific problems encountered in use of each type of electrolytic cells, the control systems for each are discussed separately.

1) Vertical Spike Soderberg Cell - Gases and dusts from the bath can be collected by a hood around the bottom of the anode. The dust content of the raw gas is reduced in the collection system by burning the tar components in combination with the carbon monoxide with a burner located in the collection channel. The final treatment of the gas consists of passage through a dry cyclone to collect the coarse particles (in some installations followed by a filter) followed by two to three stages of wet scrubbers that use water to recover the hydrogen fluoride. A final stage of alkaline scrubbing may be required to remove sulfur dioxide and the remaining fluoride.

2) Horizontal Spike Soderberg Cells - The arrangement of the spikes in horizontal spike soderberg cells makes it difficult to effect a good seal around the anode, and therefore large quantities of diluting air enter the gas cleaning system. The dilution is so great that combustion to destroy the tars in neither economical nor feasible.

One installation in Canada reportedly has overcome the problem of tar interference in the wet scrubber operation by using a turbulent bed scrubber. The combined action of an upward flow of gas and the downward flow of the scrubbing liquid maintains the spheres in a loose assembly and promotes intimate mixing. Turbulence around the loose spheres keeps them free of tars and dirt.

Field tests have shown that this type of scrubber can remove 90 percent or more of hydrogen fluoride.

(3) Prebaked Cells - When cells with prebaked anodes are used, it is difficult to draw off furnace gases in concentrated form directly from the cells because of the large number of anodes. On these pots, an exhaust hood usually encloses the active area and maintains it at a slightly negative pressure.

Pollution control equipment used with the prebaked cell consists of a dry cyclone or electrostatic precipitator for removal of particulates, followed by a wet scrubber to absorb the highly soluble hydrogen fluoride, and the remaining traces of fluoride particulates.

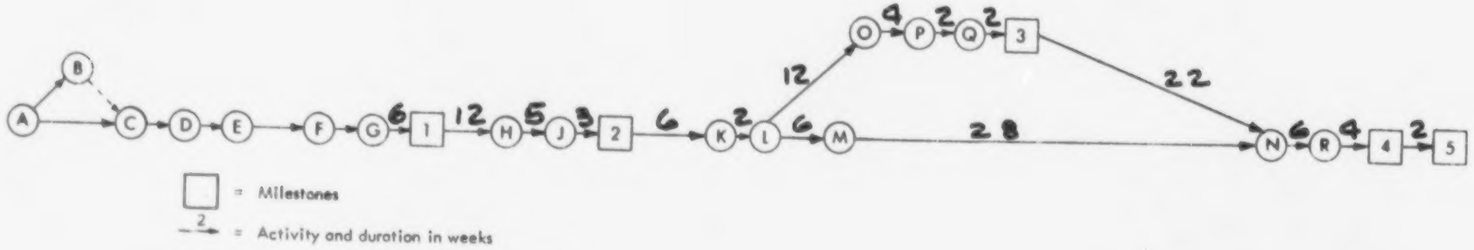
A more recent method for recovering gaseous fluorides from prebaked potlines, entails the use of a heavy bed of alumina, which is continually added on the upper crust of the cell. Contaminants are removed by filtering the gases through the bed of alumina; stray particulates are captured by a baghouse further down stream.

Compliance Schedules - Figures 3.6.11 , 3.6.12 , and 3.6.13 , respectively, illustrate expeditious schedules for installation of a wet scrubber system, a fabric filter, and an electrostatic precipitator. The complexity of the ductwork and hooding systems required for effective control were considered in developing the schedules. Additional time was included to reflect the extra work required for their design, fabrication, and installation. No compliance schedule is shown for installation of dry cyclones or afterburners since they can be installed relatively quickly and construction can be accomplished within the elapsed time shown for any of the other control devices mentioned.

Sources of Additional Information

Source	Type of Information
1) Kirk Othmer's Encyclopedia of Chemical Technology. Vol. 1, 2nd Edition Interscience Publishers	P
2) Air Pollution Control Field Operations Manual. Vol. III, Revised Edition System Development Corp. Contract No. CPA 70-122	P
3) Air Pollution Abatement on Primary Aluminum Potlines. Rush, D. et al. Journal of the Air Pollution Control Association, Vol. 23, No. 2, Feb. 1973	P,C,E

Figure 3.6.11 Schedule for installation of a wet scrubber on a primary aluminum reduction operation for particulate pollutant and fluoride emissions control.



MILESTONES

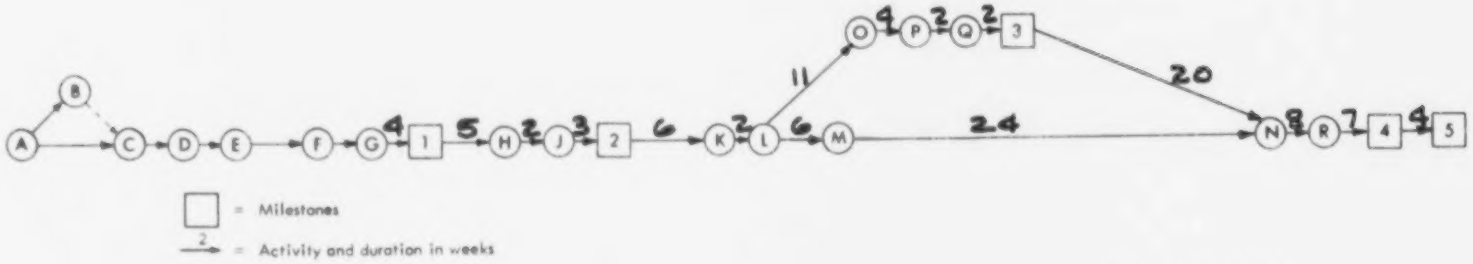
		ELAPSED TIME (WEEKS)
1	Date of submittal of final control plan to appropriate agency.	6
2	Date of award of control device contract.	26
3	Date of initiation of on-site construction or installation of emission control equipment.	54
4	Date by which on-site construction or installation of emission control equipment is completed.	86
5	Date by which final compliance is achieved.	88

ACTIVITIES

Designation	
A-C	Preliminary investigation
A-B	Source tests
C-D	Evaluate control alternatives
D-E	Commit funds for total program
E-F	Prepare preliminary control plan and compliance schedule for agency
F-G	Agency review and approval
G-1	Finalize plans and specifications
1-H	Procure control device bids
H-J	Evaluate control device bids
J-2	Award control device contract
2-K	Vendor prepares assembly drawings

Designation	
K-L	Review and approval of assembly drawings
L-M	Vendor prepares fabrication drawings
M-N	Fabricate control device
L-O	Prepare engineering drawings
O-P	Procure construction bids
P-Q	Evaluate construction bids
Q-3	Award construction contract
3-N	On-site construction
N-R	Install control device
R-4	Complete construction (system tie-in)
4-5	Startup, shakedown, preliminary source test

Figure 3.6.12 Schedule for installation of a fabric filter on a primary aluminum reduction operation for particulate pollutant control.



MILESTONES

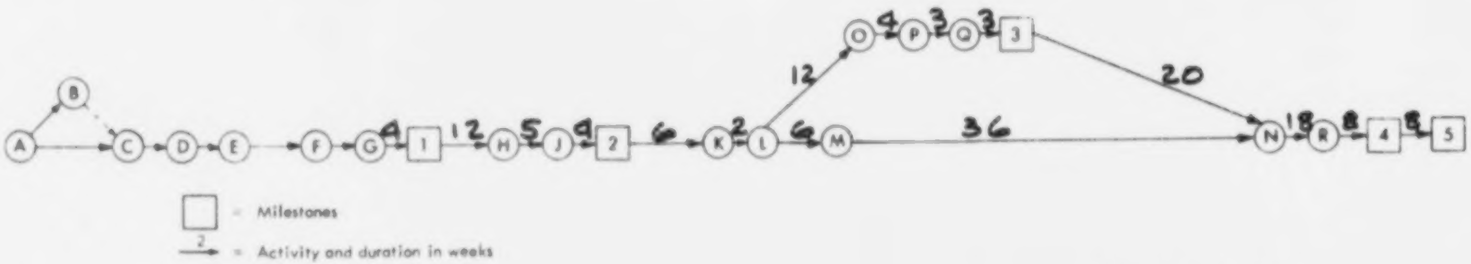
		ELAPSED TIME (WEEKS)
1	Date of submittal of final control plan to appropriate agency.	4
2	Date of award of control device contract.	14
3	Date of initiation of on-site construction or installation of emission control equipment.	41
4	Date by which on-site construction or installation of emission control equipment is completed.	76
5	Date by which final compliance is achieved.	80

ACTIVITIES

Designation	
A-C	Preliminary investigation
A-B	Source tests
C-D	Evaluate control alternatives
D-E	Commit funds for total program
E-F	Prepare preliminary control plan and compliance schedule for agency
F-G	Agency review and approval
G-1	Finalize plans and specifications
1-H	Procure control device bids
H-J	Evaluate control device bids
J-2	Award control device contract
2-K	Vendor prepares assembly drawings

Designation	
K-L	Review and approval of assembly drawings
L-M	Vendor prepares fabrication drawings
M-N	Fabricate control device
L-O	Prepare engineering drawings
O-P	Procure construction bids
P-Q	Evaluate construction bids
Q-3	Award construction contract
3-N	On-site construction
N-R	Install control device
R-4	Complete construction (system tie-in)
4-5	Startup, shakedown, preliminary source test

Figure 3.6.13 Schedule for installation of an electrostatic precipitator on a primary aluminum operation for particulate pollutant control.



MILESTONES		ELAPSED TIME (WEEKS)
1	Date of submittal of final control plan to appropriate agency.	4
2	Date of award of control device contract.	25
3	Date of initiation of on-site construction or installation of emission control equipment.	55
4	Date by which on-site construction or installation of emission control equipment is completed.	101
5	Date by which final compliance is achieved.	109

ACTIVITIES

Designation	
A-C	Preliminary investigation
A-B	Source tests
C-D	Evaluate control alternatives
D-E	Commit funds for total program
E-F	Prepare preliminary control plan and compliance schedule for agency
F-G	Agency review and approval
G-1	Finalize plans and specifications
1-H	Procure control device bids
H-J	Evaluate control device bids
J-2	Award control device contract
2-K	Vendor prepares assembly drawings

Designation	
K-L	Review and approval of assembly drawings
L-M	Vendor prepares fabrication drawings
M-N	Fabricate control device
L-O	Prepare engineering drawings
O-P	Procure construction bids
P-Q	Evaluate construction bids
Q-3	Award construction contract
3-N	On-site construction
N-R	Install control device
R-4	Complete construction (system tie-in)
4-5	Startup, shakedown, preliminary source test

3.6.4 Ferroalloys

Process Description - Ferroalloys, the generic term for alloys consisting of iron and one or more other metals, are used for deoxidation, alloying, and graphitization of steel. They can be classified into three basic types according to the major non-ferrous constituent: (1) silicon-based alloys, such as ferrosilicon; (2) manganese-based alloys, such as ferromanganese; and (3) chromium-based alloys, such as ferrochromium.

Blast furnaces and electric arc furnaces are both used to produce ferroalloys. Ferromanganese is produced in blast furnaces by the reduction of iron ore and manganese ore with coke in the presence of limestone. Approximately 75 percent of ferroalloys, however, are produced in electric arc furnaces.

Other ferroalloy manufacturing processes, used to a much lesser extent, are the alumino silico-thermic process and the electrolytic deposition process.

Atmospheric Emissions - Particulates emitted from the furnace are the primary emission problem. The chemical and physical properties of the particulates depend upon the alloy being produced and the type of furnace. Particle sizes generally range from 0.1 to 1.0 micron, with a geometric mean of approximately 0.3 micron.

Particulate emission from silicon alloy manufacture contains a high percentage of SiO_2. Some tars and carbon are also present due to the coal, coke or wood chips used in the charge. Chromium furnaces produce SiO_2 fume similar to a ferrosilicon operation with some additional chromium oxides. Manganese operations produce a brown fume, largely a mixture of SiO_2 and manganese oxides.

Control Systems - Blast furnace emissions are most commonly controlled by a high-energy wet scrubber. Electric furnaces can use either the open or closed furnace hooding design. In open furnaces all the CO produced burns with induced air at the top of the charge, resulting in a large volume of high-temperature gas. In closed furnaces most or all of the CO is withdrawn from the furnace without combustion with air.

High-energy venturi scrubbers are the most commonly used control device for both open and closed furnaces. The pressure drop required for high-efficiency particulate collection is about 60 inches water gauge for a ferrosilicon or ferrochrome-silicon operation. Substantially all of the sulfur in the reducing agent appears in the gas phase, creating a potential corrosion problem for liquid recycle systems unless neutralizing agents or special materials of construction are used.

Fabric filters can also operate effectively provided the gas temperature is reduced to below 500°F. However, in silica fume collection, a buildup of electrostatic charge occurs, leading to a high residual pressure drop across the bags.

Electrostatic precipitators have been used only to a limited extent.

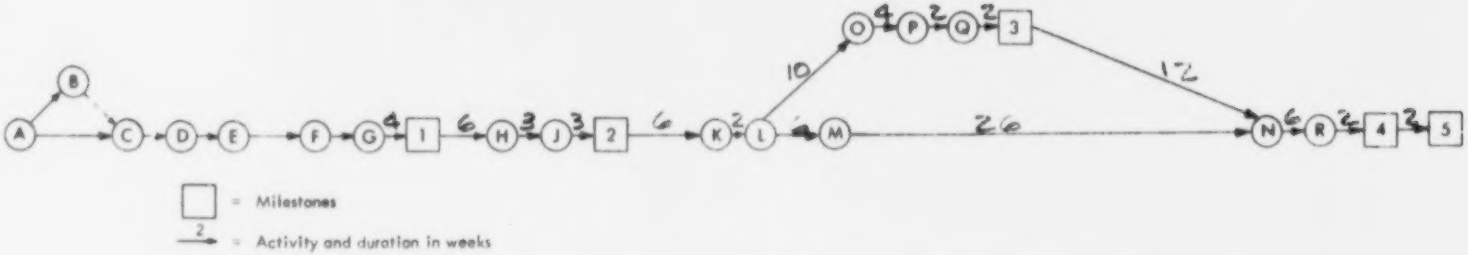
Compliance Schedules - Figures 3.6.14, 3.6.15, and 3.6.16, respectively, illustrate expeditious schedules for installing a high-energy wet scrubber system, a fabric filter, and an electrostatic precipitator on ferroalloy furnaces.

Sources of Additional Information

Source	Type of Information*
1) Handbook of Emissions, Effluents and Control Practices for Stationary Particulate Pollution Sources. NTIS Publication No. PB-203-128	P,E,C

* P = Process description
E = Emission rates
C = Control devices

Figure 3.6.14 Schedule for installation of a wet scrubber on a ferroalloy furnace for particulate pollutant control.

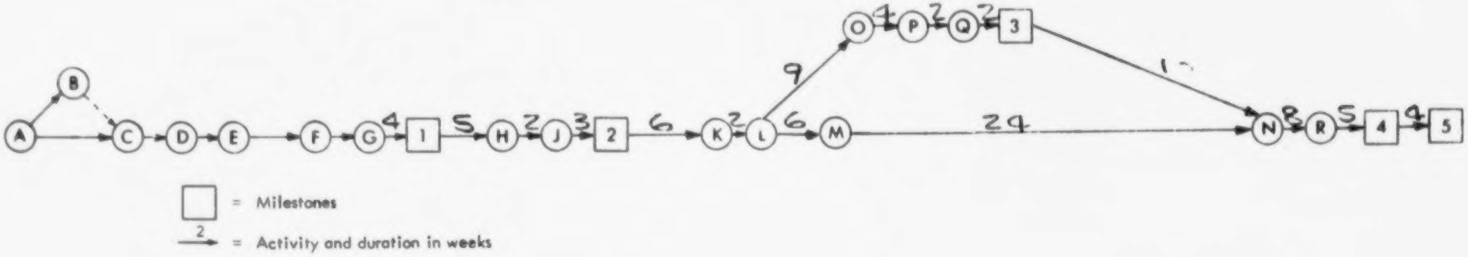


MILESTONES		ELAPSED TIME (WEEKS)
1	Date of submittal of final control plan to appropriate agency.	4
2	Date of award of control device contract.	16
3	Date of initiation of on-site construction or installation of emission control equipment	42
4	Date by which on-site construction or installation of emission control equipment is completed.	64
5	Date by which final compliance is achieved.	66

ACTIVITIES

Designation		Designation	
A-C	Preliminary investigation	K-L	Review and approval of assembly drawings
A-B	Source tests	L-M	Vendor prepares fabrication drawings
C-D	Evaluate control alternatives	M-N	Fabricate control device
D-E	Commit funds for total program	L-O	Prepare engineering drawings
E-F	Prepare preliminary control plan and compliance schedule for agency	O-P	Procure construction bids
F-G	Agency review and approval	P-Q	Evaluate construction bids
G-1	Finalize plans and specifications	Q-3	Award construction contract
1-H	Procure control device bids	3-N	On-site construction
H-J	Evaluate control device bids	N-R	Install control device
J-2	Award control device contract	R-4	Complete construction (system tie-in)
2-K	Vendor prepares assembly drawings	4-5	Startup, shakedown, preliminary source test

Figure 3.6.15 Schedule for installation of a fabric filter with pre-cooler on a ferroalloy furnace for particulate pollutant control.



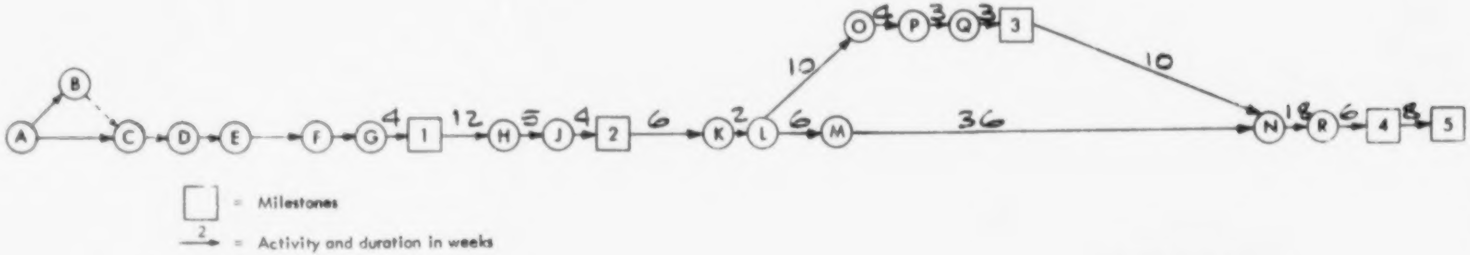
MILESTONES		ELAPSED TIME (WEEKS)
1	Date of submittal of final control plan to appropriate agency.	4
2	Date of award of control device contract.	19
3	Date of initiation of on-site construction or installation of emission control equipment.	37
4	Date by which on-site construction or installation of emission control equipment is completed.	65
5	Date by which final compliance is achieved.	69

ACTIVITIES

Designation	
A-C	Preliminary investigation
A-B	Source tests
C-D	Evaluate control alternatives
D-E	Commit funds for total program
E-F	Prepare preliminary control plan and compliance schedule for agency
F-G	Agency review and approval
G-1	Finalize plans and specifications
1-H	Procure control device bids
H-J	Evaluate control device bids
J-2	Award control device contract
2-K	Vendor prepares assembly drawings

Designation	
K-L	Review and approval of assembly drawings
L-M	Vendor prepares fabrication drawings
M-N	Fabricate control device
L-O	Prepare engineering drawings
O-P	Procure construction bids
P-Q	Evaluate construction bids
Q-3	Award construction contract
3-N	On-site construction
N-R	Install control device
R-4	Complete construction (system tie-in)
4-5	Startup, shakedown, preliminary source test

Figure 3.6.16 Schedule for installation of an electrostatic precipitator on a ferroalloy furnace.



MILESTONES		ELAPSED TIME (WEEKS)
1	Date of submittal of final control plan to appropriate agency.	4
2	Date of award of control device contract.	25
3	Date of initiation of on-site construction or installation of emission control equipment.	63
4	Date by which on-site construction or installation of emission control equipment is completed.	99
5	Date by which final compliance is achieved.	107

ACTIVITIES

Designation	
A-C	Preliminary investigation
A-B	Source tests
C-D	Evaluate control alternatives
D-E	Commit funds for total program
E-F	Prepare preliminary control plan and compliance schedule for agency
F-G	Agency review and approval
G-1	Finalize plans and specifications
1-H	Procure control device bids
H-J	Evaluate control device bids
J-2	Award control device contract
2-K	Vendor prepares assembly drawings

Designation	
K-L	Review and approval of assembly drawings
L-M	Vendor prepares fabrication drawings
M-N	Fabricate control device
L-O	Prepare engineering drawings
O-P	Procure construction bids
P-Q	Evaluate construction bids
Q-3	Award construction contract
3-N	On-site construction
N-R	Install control device
R-4	Complete construction (system tie-in)
4-5	Startup, shakedown, preliminary source test

3.7 Secondary Metallurgical Processes

3.7.1 Aluminum

Process Description - Secondary aluminum operations involve remelting of metal alloys to make castings and ingots. Depending on the source of the aluminum, the process may also include removal of impurities in the melt and introduction of alloying metals to obtain desired properties in the casting. Figure 3.7.1 illustrates the secondary aluminum process.

Impurities are usually removed by fluxing, a term applied to any process in which materials are added to the melt to aid in the removal of gases, oxides, or other impurities but do not remain in the final product. Alloying is accomplished by adding a compound containing the desired alloying metal. For example, zinc chloride and zinc fluoride can be used to increase the zinc content of aluminum alloys.

Demagging, which reduces the magnesium content of the melt, is accomplished by injecting chlorine gas into the molten bath. The chlorine reacts to form primarily magnesium chloride and some aluminum chlorides, which further react with magnesium to form additional magnesium chloride and aluminum.

The metal is melted in crucible or reverberatory furnaces. Crucible furnaces are indirectly heated and are used for melting small quantities, usually less than 1000 pounds. Reverberatory

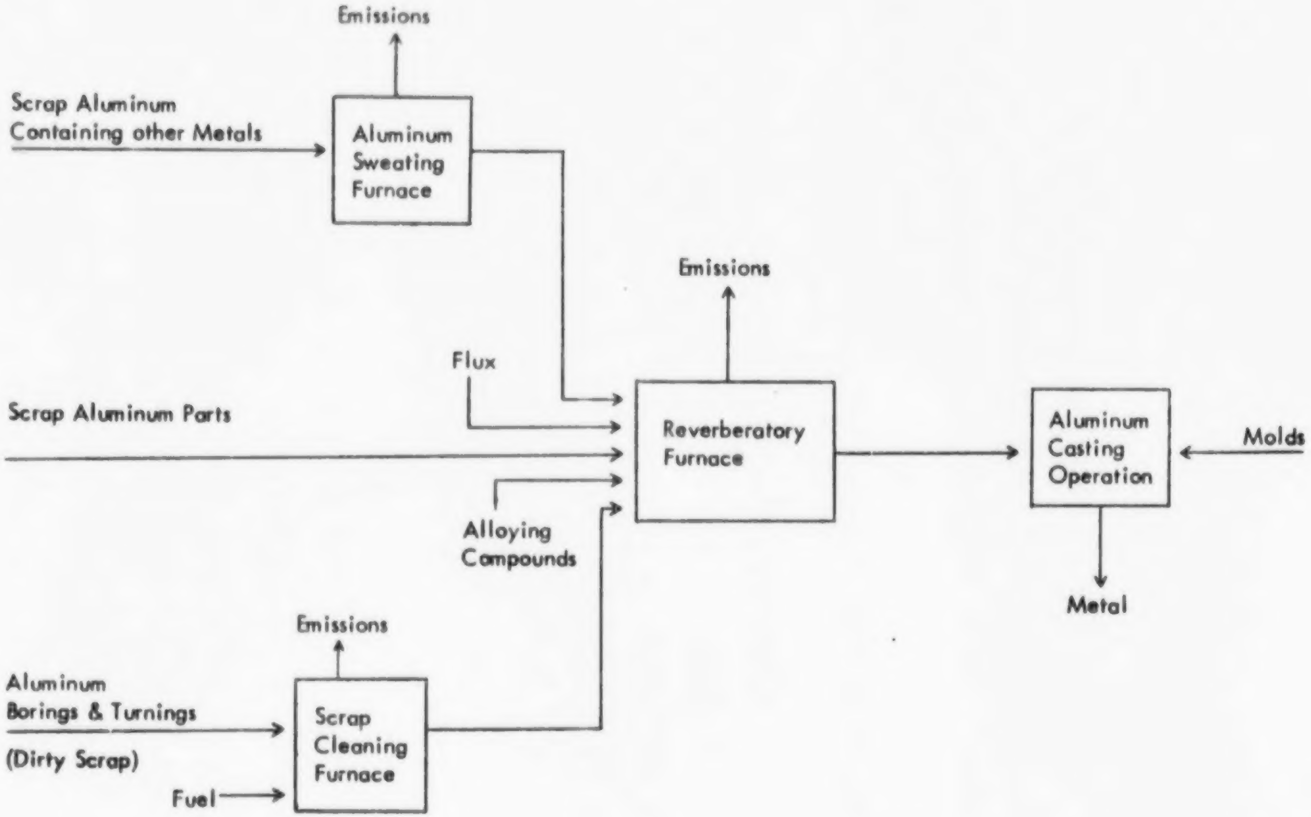

Emissions
Scrap Aluminum Containing other Metals
Aluminum Sweating Furnace
Emissions
Flux
Scrap Aluminum Parts
Reverberatory Furnace
Aluminum Casting Operation
Molds
Alloying Compounds
Metal
Emissions
Aluminum Borings & Turnings
(Dirty Scrap)
Scrap Cleaning Furnace
Fuel

Figure 3.7.1 Secondary aluminum process.

furnaces are directly fired and are used for medium and large batches of 2,000 to 20,000 pounds.

Sweat furnaces are commonly used in secondary aluminum operations to separate the aluminum from iron and other metals. Facilities that process borings or turnings from fabricating operations often use gas- or oil-fired furnaces to burn off the cutting oils and grease before the metal is charged into the melting furnace.

The core making and sand handling systems are integral parts of the foundry. These processes, their emissions, and control methods, with expeditious schedules for installing the control devices, are described in Section 3.7.8.

Atmospheric Emissions - The melting of clean aluminum pigs and foundry returns without the use of fluxes does not create significant atmospheric emissions. The melting of aluminum scrap, however, requires air pollution control equipment to prevent the discharge of excessive emissions, consisting primarily of magnesium and aluminum chloride fumes, which react with moisture in the air to form magnesium and aluminum oxides and hydrogen chloride.

Particulate emissions from the sweating furnaces amount to approximately 15 pounds per ton of metal processed. Reverberatory furnaces emit from 2 to 4 pounds per ton; the chlorination station emits about 1000 pounds of particulates per ton of chlorine consumed.

Control Systems - Fabric filters and wet scrubbers are used to control emissions from reverberatory and crucible furnaces, with fabric filters predominating. An afterburner is also required on sweating furnaces because the effluent is oily and combustible. In operation of a fabric filter/afterburner combination the exhause gases of the afterburner must be cooled by either evaporative or radiant cooling to protect the fabric. Air-to-cloth ratios of approximately 2:1 are used for the fabric filter. Dacron is the most commonly used fabric. High-energy venturi scrubbers require as much as 40 to 50 inches water gauge pressure drop to provide the required collection efficiencies.

For the chlorination station, a wet scrubbing system consisting of a high-energy venturi contactor followed by a gas absorption tower, is required for effective control of both the submicron particulates and the HCl and Cl_2 emissions. Pressure drops of 50 to 60 inches water gauge may be required to control particulate emissions effectively.

Compliance Schedules - Figure 3.7.2 illustrates an expeditious schedule for installing either a fabric filter or fabric filter/afterburner control system. Figure 3.7.3 illustrates an expeditious schedule for installing either a wet scrubber or wet scrubber/afterburner control system. Figure 3.7.4 illustrates an expeditious schedule for installation of an afterburner on a scrap cleaning furnace.

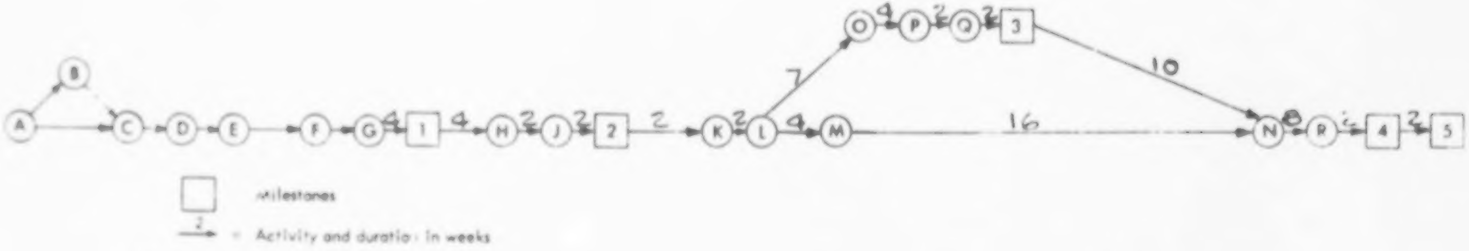
Figure 3.7.5 illustrates an expeditious schedule for installing a custom designed baghouse or baghouse/afterburner system where it is required due to such factors as space limitations and unique process configurations. This schedule is sufficient to accommodate simultaneous modification to a furnace if required.

Sources of Additional Information

Source	Type of Information*
1) Air Pollution Engineering Manual Public Health Service Publication No. 999-AP-40	P,C
2) Exhaust Gases from Combustion and Industrial Processes NTIS PB 204-861	P,C
3) Study of Technical and Cost Information for Gas Cleaning Equipment in the Lime and Secondary Non-Ferrous Metallurgical Industries NTIS PB 198-137	P,E,C

* P = Process description
E = Emission rates
C = Control devices

Figure 3.7.2 Schedule for installation of a fabric filter or fabric filter/afterburner control system for particulate pollutant control.



MILESTONES

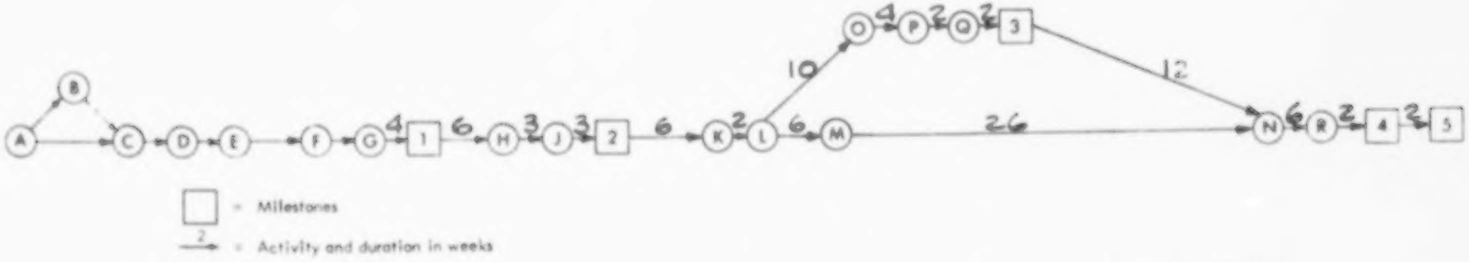
		ELAPSED TIME (WEEKS)
1	Date of submittal of final control plan to appropriate agency.	4
2	Date of award of control device contract.	12
3	Date of initiation of on-site construction or installation of emission control equipment.	31
4	Date by which on-site construction or installation of emission control equipment is completed.	51
5	Date by which final compliance is achieved.	53

ACTIVITIES

Designation	
A-C	Preliminary investigation
A-B	Source tests
C-D	Evaluate control alternatives
D-E	Commit funds for total program
E-F	Prepare preliminary control plan and compliance schedule for agency
F-G	Agency review and approval
G-1	Finalize plans and specifications
1-H	Procure control device bids
H-J	Evaluate control device bids
J-2	Award control device contract
2-K	Vendor prepares assembly drawings

Designation	
K-L	Review and approval of assembly drawings
L-M	Vendor prepares fabrication drawings
M-N	Fabricate control device
L-O	Prepare engineering drawings
O-P	Procure construction bids
P-Q	Evaluate construction bids
Q-3	Award construction contract
3-N	On-site construction
N-R	Install control device
R-4	Complete construction (system tie-in)
4-5	Startup, shakedown, preliminary source test

Figure 3.7.3 Schedule for installation of a wet scrubber or wet scrubber/afterburner control system for particulate pollutant control.



MILESTONES

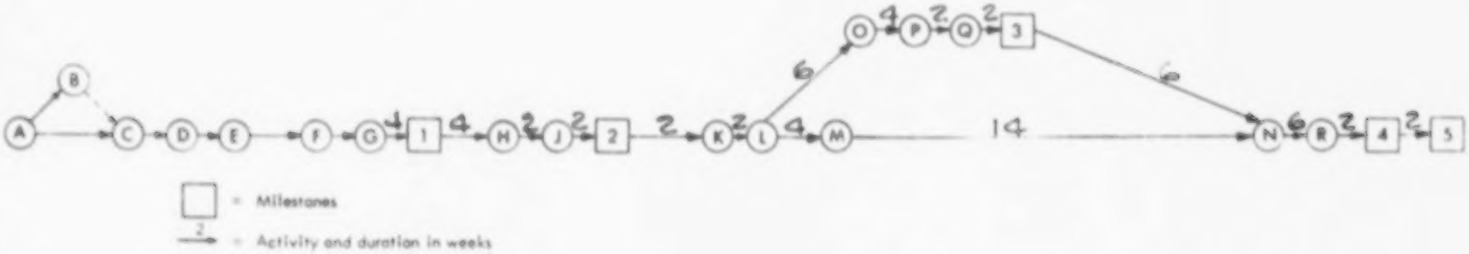
		ELAPSED TIME (WEEKS)
1	Date of submittal of final control plan to appropriate agency.	4
2	Date of award of control device contract.	16
3	Date of initiation of on-site construction or installation of emission control equipment.	42
4	Date by which on-site construction or installation of emission control equipment is completed.	64
5	Date by which final compliance is achieved.	66

ACTIVITIES

Designation	
A-C	Preliminary investigation
A-B	Source tests
C-D	Evaluate control alternatives
D-E	Commit funds for total program
E-F	Prepare preliminary control plan and compliance schedule for agency
F-G	Agency review and approval
G-1	Finalize plans and specifications
1-H	Procure control device bids
H-J	Evaluate control device bids
J-2	Award control device contract
2-K	Vendor prepares assembly drawings

Designation	
K-L	Review and approval of assembly drawings
L-M	Vendor prepares fabrication drawings
M-N	Fabricate control device
L-O	Prepare engineering drawings
O-P	Procure construction bids
P-Q	Evaluate construction bids
Q-3	Award construction contract
3-N	On-site construction
N-R	Install control device
R-4	Complete construction (system tie-in)
4-5	Startup, shakedown, preliminary source test

Figure 3.7.4 Schedule for installation of an afterburner for control of hydrocarbon and combustible particulate emissions.



MILESTONES

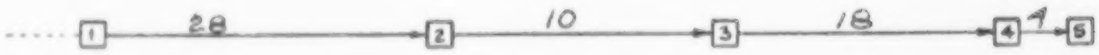
		ELAPSED TIME (WEEKS)
1	Date of submittal of final control plan to appropriate agency.	4
2	Date of award of control device contract.	12
3	Date of initiation of on-site construction or installation of emission control equipment.	30
4	Date by which on-site construction or installation of emission control equipment is completed.	44
5	Date by which final compliance is achieved.	46

ACTIVITIES

Designation	
A-C	Preliminary investigation
A-B	Source tests
C-D	Evaluate control alternatives
D-E	Commit funds for total program
E-F	Prepare preliminary control plan and compliance schedule for agency
F-G	Agency review and approval
G-1	Finalize plans and specifications
1-H	Procure control device bids
H-J	Evaluate control device bids
J-2	Award control device contract
2-K	Vendor prepares assembly drawings

Designation	
K-L	Review and approval of assembly drawings
L-M	Vendor prepares fabrication drawings
M-N	Fabricate control device
L-O	Prepare engineering drawings
O-P	Procure construction bids
P-Q	Evaluate construction bids
Q-3	Award construction contract
3-N	On-site construction
N-R	Install control device
R-4	Complete construction (system tie-in
4-5	Startup, shakedown, preliminary source test

Figure 3.7.5 Schedule for installation of custom-designed fabric filter for particulate pollutant control.



MILESTONES		ELAPSED TIME (WEEKS)
1	Date of submittal of final control plan to appropriate agency.	0
2	Date of award of control device contract.	28
3	Date of initiation of on-site construction or installation of emission control equipment.	38
4	Date by which on-site construction of emission control equipment is completed.	56
5	Date by which final compliance is achieved.	60

ACTIVITIES

DESIGNATIONS	
1 - 2	Preparation of detailed engineering and fabrication drawings, equipment specifications, construction bid documents and award of construction contract.
2 - 3	Equipment fabrication and delivery of structural components to site.
3 - 4	Delivery of remaining equipment and completion of construction including process tie in.
4 - 5	Equipment start up and source testing.

3.7.2 Brass and Bronze

Process Description - Brass and bronze production involves a wide variety of melting, refining, and casting operations to produce the copper or copper-based alloys. Raw materials in the form of ingots and/or scrap are melted in a furnace and various fluxes are added to refine the metal. The molten metal is then poured into smaller pots and transferred to the casting area, where it is poured into molds. After the metal cools, the sand mold material is separated from the metal in the shake-out area. The casting is then cleaned and processed, and the sand mold material is recycled.

A number of melting furnaces are used in this industry, including gas- and oil-fired reverberatory and rotary furnaces, and electric induction units.

The core making and sand handling systems are integral parts of a brass and bronze foundry. These processes, emissions, and control methods plus expeditious schedules for installing the control devices, are described in Section 3.7.8.

Atmospheric Emissions - The melting operation represents the primary source of particulate emissions. Particulate composition depends on the metals being melted and the flux material used. The quantity of particulate emitted depends primarily on the type of melting furnace used. Alloys containing zinc, tin, and magnesium tend to produce higher emission levels because of their higher volatility. Direct-fired furnaces, such as the reverberatory furnace, produce higher emission levels than indirect-fired units.

Careful temperature control, proper flux cover, and addition of alloying metals before the melt is started all tend to reduce emissions.

Other sources of particulate emissions include the mold and casting handling and preparation areas. These sources are relatively minor as compared with the furnace emissions.

Control Methods - Both process changes and control systems can be used to reduce emissions. The use of crucible or pot furnaces, fired externally with gas or light oil, or the use of electric induction furnaces, can greatly reduce the amount of fume generated in the melting processes.

Particulate control can also be achieved by the installation of fabric filter systems. The small particle sizes and the potential presence of hazardous metal compounds require a highly efficient control system. Air-to-cloth ratios on the order of 3:1 are commonly used.

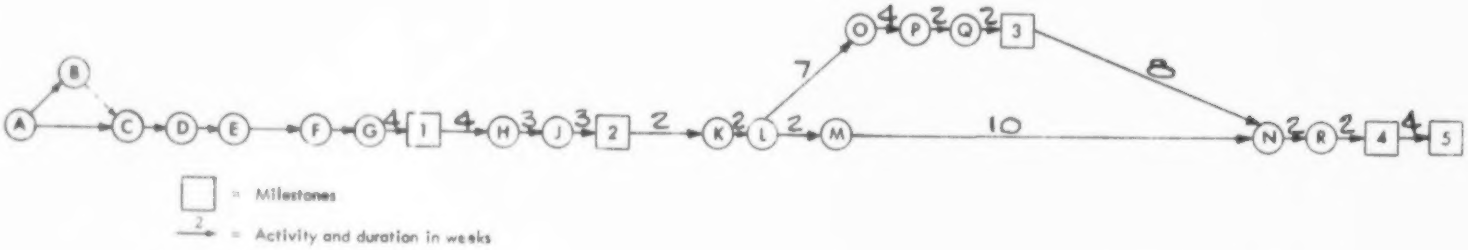
Compliance Schedules - An expeditious schedule for installation of a fabric filter to control emissions from a brass and bronze foundry is shown in Figure 3.7.6.

Sources of Additional Information

	Source	Type of Information*
1)	Air Pollution Aspects of Brass and Bronze Smelting and Refining Industry National Air Pollution Control Administration AP-58	E,C
2)	Air Pollution Engineering Manual Public Health Service Publication 999-AP-40	P,C

* P = Process description
E = Emission rates
C = Control devices

Figure 3.7.6 Schedule for installation of a fabric filter on a brass and bronze foundry for particulate pollutant control.



MILESTONES

		ELAPSED TIME (WEEKS)
1	Date of submittal of final control plan to appropriate agency.	4
2	Date of award of control device contract.	14
3	Date of initiation of on-site construction or installation of emission control equipment.	33
4	Date by which on-site construction or installation of emission control equipment is completed.	45
5	Date by which final compliance is achieved.	49

ACTIVITIES

Designation	
A-C	Preliminary investigation
A-B	Source tests
C-D	Evaluate control alternatives
D-E	Commit funds for total program
E-F	Prepare preliminary control plan and compliance schedule for agency
F-G	Agency review and approval
G-1	Finalize plans and specifications
1-H	Procure control device bids
H-J	Evaluate control device bids
J-2	Award control device contract
2-K	Vendor prepares assembly drawings

Designation	
K-L	Review and approval of assembly drawings
L-M	Vendor prepares fabrication drawings
M-N	Fabricate control device
L-O	Prepare engineering drawings
O-P	Procure construction bids
P-Q	Evaluate construction bids
Q-3	Award construction contract
3-N	On-site construction
N-R	Install control device
R-4	Complete construction (system tie-in)
4-5	Startup, shakedown, preliminary source test

3.7.3 Steel

Process Description - Steel foundries differ from the basic iron and steel plants since their primary raw material is scrap steel. They produce cast steel, usually for heavy industrial uses, such as bulldozer frames and locomotive wheels.

Three types of furnaces are in common use: direct electric-arc, electric induction, and open hearth. Scrap, pig iron, ferroalloys, and limestone are charged to the furnace. Refined steel is produced in the melt by oxidizing the impurities, reducing the iron oxide, and adding the desired alloying constituents.

Atmospheric Emissions - Particulate emissions from steel foundry operations include iron oxide fumes, sand fines, graphite, and metal dust. Hydrocarbons can also be emitted if dirty scrap is charged. Primary factors influencing the quantity of pollutants emitted are the quality and cleanliness of the scrap and the amount of oxygen lancing used.

Particulate emissions from the electric arc furnace range between 4 and 40 pounds per ton, averaging about 13 pounds per ton of metal processed. Emissions from open-hearth furnaces average about 11 pounds of particulate per ton; electric induction furnaces emit about 0.1 pound per ton of metal processed.

Control Systems - Fabric filters and, to a lesser extent, wet scrubbers are the most commonly used control devices. Air-to-cloth ratios for the fabric filter should not exceed 2.5 to 1. Dacron and glass fiber are the most commonly used fabrics.

Compliance Schedules - Figures 3.7.7 and 3.7.8, respectively, illustrate expeditious schedules for installation of a fabric filter and a wet scrubber.

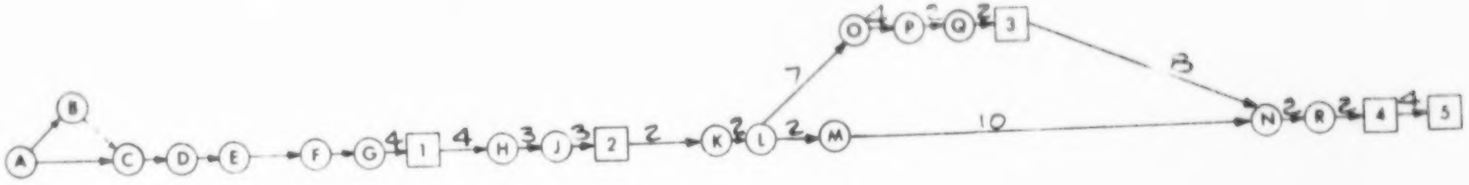
Figure 3.7.9 illustrates an expeditious schedule for installing a custom-designed fabric filter where it is required by such factors as space limitations and unique process configurations. This schedule can accommodate simultaneous modification of the furnace if required.

Sources of Additional Information

Source	Type of Information*
1) Air Pollution Engineering Manual Public Health Service Publication No. 999-AP-40	P,C
2) Exhaust Gases from Combustion and Industrial Processes NTIS Publication No. PB 204-861	P,C

* P = Process description
E = Emission rates
C = Control devices

Figure 3.7.7 Schedule for installation of a fabric filter on a steel foundry furnace for particulate pollutant control.



☐ = Milestones

$\xrightarrow{2}$ = Activity and duration in weeks

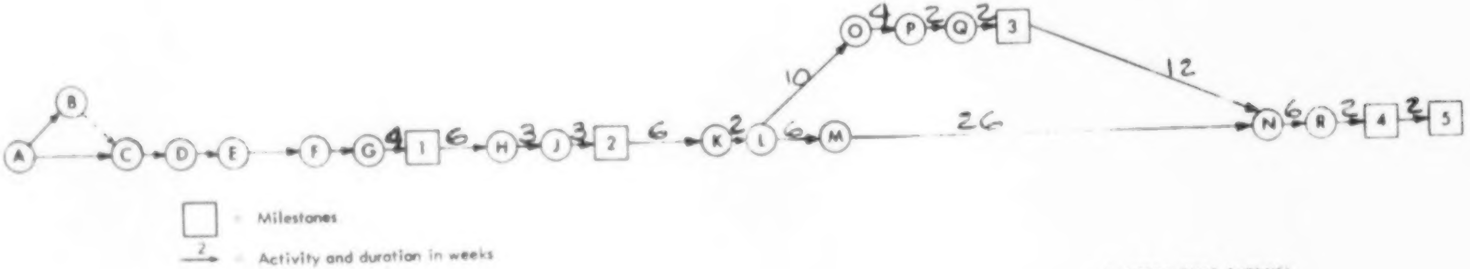
MILESTONES		ELAPSED TIME (WEEKS)
1	Date of submittal of final control plan to appropriate agency.	4
2	Date of award of control device contract.	14
3	Date of initiation of on-site construction or installation of emission control equipment.	33
4	Date by which on-site construction or installation of emission control equipment is completed.	45
5	Date by which final compliance is achieved.	49

ACTIVITIES

Designation	
A-C	Preliminary investigation
A-B	Source tests
C-D	Evaluate control alternatives
D-E	Commit funds for total program
E-F	Prepare preliminary control plan and compliance schedule for agency
F-G	Agency review and approval
G-1	Finalize plans and specifications
1-H	Procure control device bids
H-J	Evaluate control device bids
J-2	Award control device contract
2-K	Vendor prepares assembly drawings

Designation	
K-L	Review and approval of assembly drawings
L-M	Vendor prepares fabrication drawings
M-N	Fabricate control device
L-O	Prepare engineering drawings
O-P	Procure construction bids
P-Q	Evaluate construction bids
Q-3	Award construction contract
3-N	On-site construction
N-R	Install control device
R-4	Complete construction (system tie-in)
4-5	Startup, shakedown, preliminary source test

Figure 3.7.8 Schedule for installation of a wet scrubber on a steel foundry furnace for particulate pollutant control.



MILESTONES

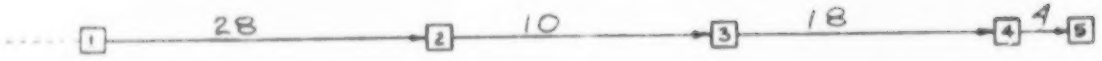
		ELAPSED TIME (WEEKS)
1	Date of submittal of final control plan to appropriate agency.	4
2	Date of award of control device contract.	16
3	Date of initiation of on-site construction or installation of emission control equipment	42
4	Date by which on-site construction or installation of emission control equipment is completed.	64
5	Date by which final compliance is achieved.	66

ACTIVITIES

Designation	
A-C	Preliminary investigation
A-B	Source tests
C-D	Evaluate control alternatives
D-E	Commit funds for total program
E-F	Prepare preliminary control plan and compliance schedule for agency
F-G	Agency review and approval
G-1	Finalize plans and specifications
1-H	Procure control device bids
H-J	Evaluate control device bids
J-2	Award control device contract
2-K	Vendor prepares assembly drawings

Designation	
K-L	Review and approval of assembly drawings
L-M	Vendor prepares fabrication drawings
M-N	Fabricate control device
L-O	Prepare engineering drawings
O-P	Procure construction bids
P-Q	Evaluate construction bids
Q-3	Award construction contract
3-N	On-site construction
N-R	Install control device
R-4	Complete construction (system tie-in)
4-5	Startup, shakedown, preliminary source test

Figure 3.7.9 Schedule for installation of a custom designed fabric filter for particulate pollutant control.



MILESTONES		ELAPSED TIME (WEEKS)
1	Date of submittal of final control plan to appropriate agency.	0
2	Date of award of control device contract.	28
3	Date of initiation of on-site construction or installation of emission control equipment.	38
4	Date by which on-site construction of emission control equipment is completed.	56
5	Date by which final compliance is achieved.	60

ACTIVITIES

DESIGNATIONS	
1 - 2	Preparation of detailed engineering and fabrication drawings, equipment specifications, construction bid documents and award of construction contract.
2 - 3	Equipment fabrication and delivery of structural components to site.
3 - 4	Delivery of remaining equipment and completion of construction including process tie in.
4 - 5	Equipment start up and source testing.

3.7.4 Gray Iron

Process Description - Gray iron foundries produce a heavy, brittle metal commonly called cast iron, but named for its characteristic gray-white color. Three types of furnaces are in common use: cupolas, reverberatory furnaces, and electric induction furnaces. Cupolas, which are used to melt over 90 percent of the metal poured for gray iron castings, range in capacity from 1 to 50 tons of metal per hour. Electric furnaces are gaining in popularity, partially because of their low emission rates. Reverberatory furnaces are used in about 2 percent of the foundries.

Atmospheric Emissions - Emissions from cupolas consist primarily of metallic oxides plus products of incomplete combustion from the oils and grease adhering to the scrap. Carbon monoxide is also emitted in significant amounts because the cupola's atmosphere is oxygen deficient. Uncontrolled emission rates are approximately 15 and 150 pounds of particulates and carbon monoxide, respectively, per ton of metal charged.

Control Systems - Afterburner/fabric filter systems are most commonly used to control emissions. Afterburner/high-energy wet scrubber systems are also used, but to a more limited extent. Gas burners or torches are frequently installed directly above the charging door to control carbon monoxide and, to some extent, odor emissions. The afterburner section should be designed to allow a residence time of approximately 0.5 second and a minimum temperature of 1200°F. The gases from the afterburner must be cooled by air dilution, radiant cooling, or quenching with water to protect the fabric filter. Air dilution and radiant cooling are usually preferred since they minimize the chances of fabric blinding. Air-to-cloth ratios for the fabric filter are typically 2 to 1.

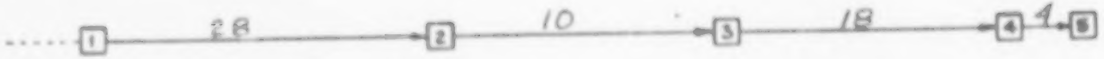
Compliance Schedules - Installation of a fabric filter/afterburner system usually requires furnace modification to reduce the volume of exhaust air that must be treated. Figure 3.7.10 illustrates an expeditious schedule for installing a fabric filter/afterburner system with simultaneous modifications of the furnace, if required. Figure 3.7.11 illustrates an expeditious schedule for installation of a high-energy wet scrubber.

Sources of Additional Information

Source	Type of Information*
1. Air Pollution Engineering Manual Public Health Service Publication No. 999-AP-40	P, E, C
2. Systems Analysis of Emissions and Control in the Iron Foundry Industry NTIS No. PB 198-348	P, E, C

* P = Process description
E = Emission rates
C = Control devices

Figure 3.7.10 Schedule for installation of a fabric filter/afterburner control system for particulate pollutant control.

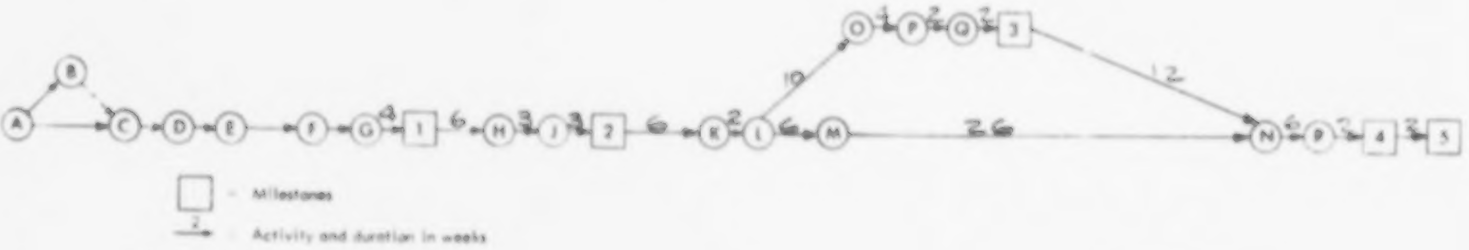


MILESTONES		ELAPSED TIME (WEEKS)
1	Date of submittal of final control plan to appropriate agency.	0
2	Date of award of control device contract.	28
3	Date of initiation of on-site construction or installation of emission control equipment.	38
4	Date by which on-site construction of emission control equipment is completed.	56
5	Date by which final compliance is achieved.	60

ACTIVITIES

DESIGNATIONS	
1 - 2	Preparation of detailed engineering and fabrication drawings, equipment specifications, construction bid documents and award of construction contract.
2 - 3	Equipment fabrication and delivery of structural components to site.
3 - 4	Delivery of remaining equipment and completion of construction including process tie in.
4 - 5	Equipment start up and source testing.

Figure 3.7.11 Schedule for installation of a high energy wet scrubber system for particulate pollutant control.



MILESTONES		ELAPSED TIME (WEEKS)
1	Date of submittal of final control plan to appropriate agency.	4
2	Date of award of control device contract.	16
3	Date of initiation of on-site construction or installation of emission control equipment.	42
4	Date by which on-site construction or installation of emission control equipment is completed.	69
5	Date by which final compliance is achieved.	66

ACTIVITIES

Designation		Designation	
A-C	Preliminary investigation	K-L	Review and approval of assembly drawings
A-B	Source tests	L-M	Vendor prepares fabrication drawings
C-D	Evaluate control alternatives	M-N	Fabricate control device
D-E	Commit funds for total program	L-O	Prepare engineering drawings
E-F	Prepare preliminary control plan and compliance schedule for agency	O-P	Procure construction bids
F-G	Agency review and approval	P-Q	Evaluate construction bids
G-1	Finalize plans and specifications	Q-3	Award construction contract
1-H	Procure control device bids	3-N	On-site construction
H-J	Evaluate control device bids	N-R	Install control device
J-2	Award control device contract	R-4	Complete construction (system tie-in)
2-K	Vendor prepares assembly drawings	4-5	Startup, shakedown, preliminary source test

3.7.5 Lead Smelting

Process Description - Three types of furnaces are used to produce the common grade of lead: the pot furnace, the reverberatory furnace, and the blast furnace or cupola.

Pot furnaces, which are indirectly fired, are used primarily for alloying and refining. Reverberatory furnaces are used in the processing of lead scrap metal in several ways, including burnout, sweating, melting, and purification. The burnout operation involves incineration of materials present in the scrap, such as plastics, rubber insulation, wood, paper and other combustible materials. In lead sweating operations, lead is separated from a mixture of materials, many of which have higher melting points than lead. The primary use of reverberatory furnaces is for lead melting and purifying the lead by removal of extraneous ingredients. Figure 3.7.12 illustrates a lead reverberatory furnace controlled by a fabric filter.

The lead cupola is similar to the iron cupolas used in ferrous smelting operations. Unlike the reverberatory furnace, the cupola serve a very specific function: to reduce the oxidized metal. The material charged consists of lead-containing alloys, slag, coke, and limestone, with some scrap cast iron. Additional charges are added at intervals as the material melts down.

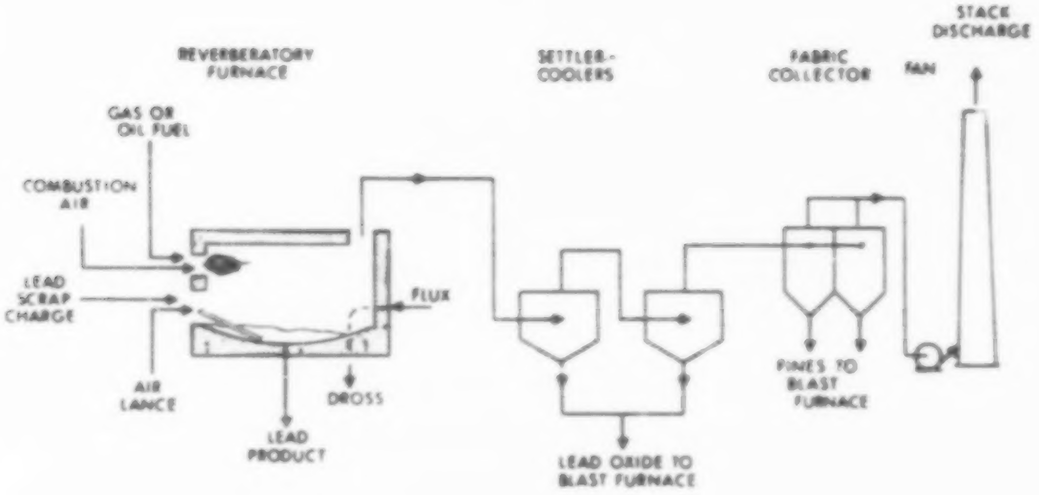

REVERBERATORY FURNACE
SETTLER-COOLERS
FABRIC COLLECTOR
FAN
STACK DISCHARGE
GAS OR OIL FUEL
COMBUSTION AIR
LEAD SCRAP CHARGE
FLUX
AIR LANCE
DROSS
LEAD PRODUCT
FINES TO BLAST FURNACE
LEAD OXIDE TO BLAST FURNACE

Figure 3.7.12 Lead reverberatory furnace.

The core making and sand handling systems are integral parts of the foundry. These processes, their emissions, and control methods, with expeditious schedules for installing the control devices, are described in Section 3.7.8.

Atmospheric Emissions - Particulate emissions from the crucible furnace are usually less than one pound per ton of material charge. Because this material is extremely hazardous, however, the process requires a high degree of control. Particulates emitted from reverberatory and blast furnaces amount to approximately 130 and 190 pounds per ton of metal processed, respectively.

Although particulates are usually the emission of primary concern, sulfur oxides, carbon monoxide, hydrocarbons, and hydrogen chloride (from decomposition of chlorine-containing materials) can also be emitted by oxidation of the sulfur content of the materials charged to the furnace (e.g. lead batteries).

Control Systems - Particulate emissions are usually controlled by fabric filters operating with air-to-cloth ratios of about 2:1. Orlon fabric is frequently used. An afterburner system may be required to complete combustion on reverberatory furnaces burning significant amounts of scrap, followed by a fabric filter or high-energy wet scrubber for particulate removal; the scrubber is capable of removing soluble gases.

Compliance Schedules - Figures 3.7.13 and 3.7.14 illustrate expeditious schedules for installation of a wet scrubber and a fabric filter system, respectively. The schedule for the wet scrubber system includes the time required to install the associated waste water treatment equipment.

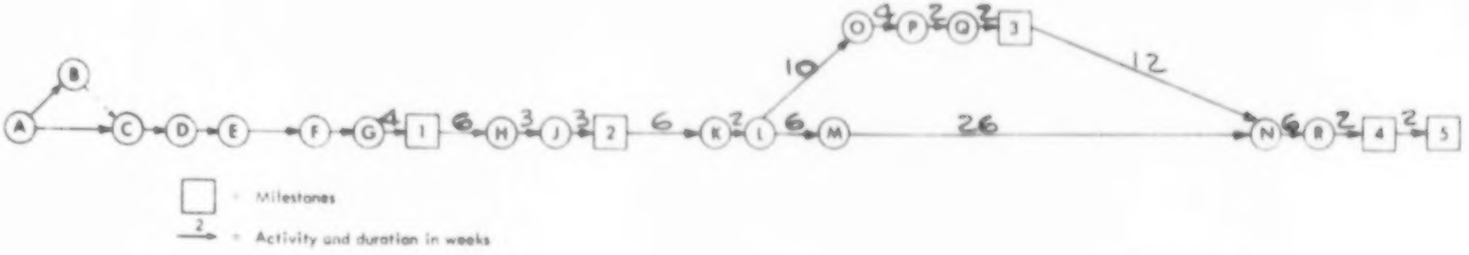
Sources of Additional Information

Source	Type of Information*
1. Air Pollution Engineering Manual Public Health Service Publication No. 999-AP-40	P, C

2. Study of Technical and Cost Information for Gas Cleaning Equipment in the Lime and Secondary Non-Ferrous Metallurgical Industries. PB 198 137	P, C, E

* P = Process description
E = Emission rates
C = Control systems

Figure 3.7.13 Schedule for installation of a wet scrubber system on lead smelting furnaces for particulate pollutant and gaseous emissions control.



MILESTONES

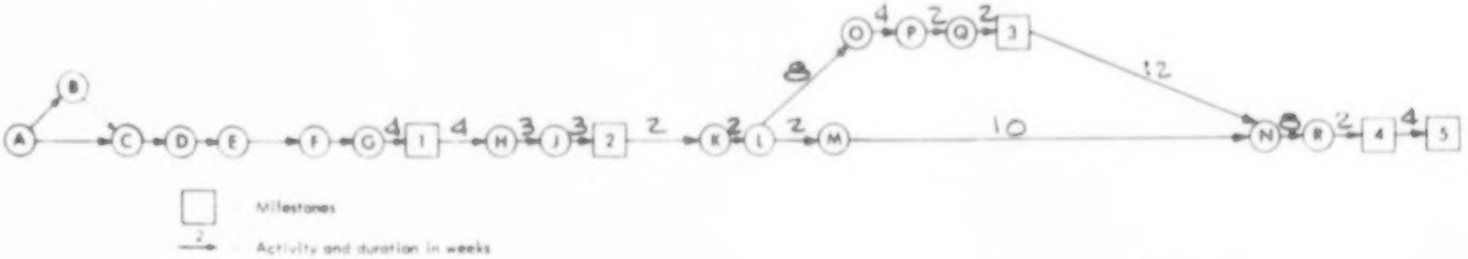
		ELAPSED TIME (WEEKS)
1	Date of submittal of final control plan to appropriate agency.	4
2	Date of award of control device contract.	16
3	Date of initiation of on-site construction or installation of emission control equipment.	42
4	Date by which on-site construction or installation of emission control equipment is completed.	64
5	Date by which final compliance is achieved	66

ACTIVITIES

Designation	
A-C	Preliminary investigation
A-B	Source tests
C-D	Evaluate control alternatives
D-E	Commit funds for total program
E-F	Prepare preliminary control plan and compliance schedule for agency
F-G	Agency review and approval
G-1	Finalize plans and specifications
1-H	Procure control device bids
H-J	Evaluate control device bids
J-2	Award control device contract
2-K	Vendor prepares assembly drawings

Designation	
K-L	Review and approval of assembly drawings
L-M	Vendor prepares fabrication drawings
M-N	Fabricate control device
L-O	Prepare engineering drawings
O-P	Procure construction bids
P-Q	Evaluate construction bids
Q-3	Award construction contract
3-N	On-site construction
N-R	Install control device
R-4	Complete construction (system tie-in)
4-5	Startup, shakedown, preliminary source test

Figure 3.7.14 Schedule for installation of an afterburner/baghouse system on lead smelting furnace for particulate pollutant control.



MILESTONES		ELAPSED TIME (WEEKS)
1	Date of submittal of final control plan to appropriate agency.	4
2	Date of award of control device contract.	14
3	Date of initiation of on-site construction or installation of emission control equipment.	34
4	Date by which on-site construction or installation of emission control equipment is completed.	56
5	Date by which final compliance is achieved.	60

ACTIVITIES

Designation	
A-C	Preliminary investigation
A-B	Source tests
C-D	Evaluate control alternatives
D-E	Commit funds for total program
E-F	Prepare preliminary control plan and compliance schedule for agency
F-G	Agency review and approval
G-1	Finalize plans and specifications
1-H	Procure control device bids
H-J	Evaluate control device bids
J-2	Award control device contract
2-K	Vendor prepares assembly drawings

Designation	
K-L	Review and approval of assembly drawings
L-M	Vendor prepares fabrication drawings
M-N	Fabricate control device
L-O	Prepare engineering drawings
O-P	Procure construction bids
P-Q	Evaluate construction bids
Q-3	Award construction contract
3-N	On-site construction
N-R	Install control device
R-4	Complete construction (system tie-in)
4-5	Startup, shakedown, preliminary source test

3.7.6 Zinc Smelting

Process Description - Secondary zinc is melted in a variety of furnaces for use in alloying, casting, and galvanizing. These furnaces include crucible (pot), kettle, reverberatory, and electric induction furnaces. Sources of the raw material are ingots, rejected castings, and scrap.

The melting operation is essentially the same in all these units. The zinc is melted and heated to its pouring temperature, between 800 and 1100°F. Before the zinc is poured, fluxing material may be added to separate the dross that accumulated during the melting operation. Dross is formed by the impurities charged with the metal and by oxidation during the melting and heating cycles. The dross is skimmed from the surface of the metal and the metal is poured into molds.

The core making and sand handling systems are integral parts of a zinc foundry. These processes, their emissions, and control methods, with expeditious schedules for installing the control devices, are described in Section 3.7.8.

Atmospheric Emissions - Particulates emitted from zinc smelting operations consist primarily of zinc oxide fumes. The emission rate depends on the cleanliness and quality of the scrap and the type of furnace used. Melting clean zinc scrap produces relatively low emissions, whereas with dirty scrap, the particulate emission is approximately 25 pounds per ton of metal produced.

The type of flux used can also affect the emission rate. Although many fluxes now in use do not fume, a specific fuming flux may be required for certain batches. For example, ammonium chloride is sometimes used; when heated to the temperature of the molten zinc, this compound decomposes into ammonia and hydrogen chloride. The ammonia and hydrogen chloride subsequently recombine to form a sub-micron fume of ammonium chloride.

Control Systems - Both process changes and control devices can be used to reduce emissions. Use of electric induction furnaces, clean scrap, and non-fuming fluxes can substantially reduce emissions.

Fabric filters made of Dacron fabric are the most commonly used control devices. The gases from the furnace must be cooled to about 250°F through either quenching or radiant cooling. Air-to-cloth ratios are typically between 2 to 1 and 3 to 1.

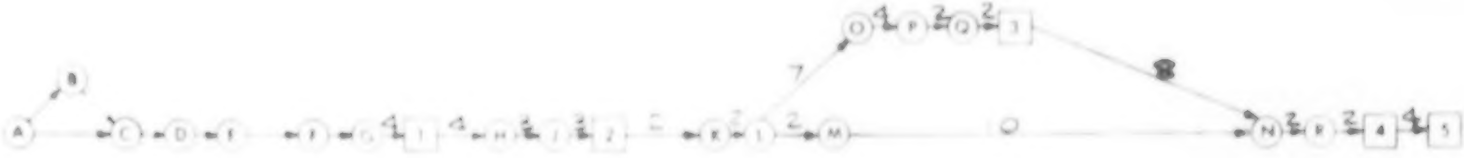
Compliance Schedules - Figure 3.7.15 illustrates an expeditious schedule for installation of a fabric filter on a secondary zinc furnace.

Sources of Additional Information

Source	Type of Information*
1. Secondary Zinc Industry Emission Control Problem Definition Study NTIS PB 201-739	P, C
2. Exhaust Gases from Combustion and Industrial Processes NTIS PB 204-861	P
3. Air Pollution Engineering Manual PHS Publication No. 999-AP-40	P, E, C

* P = Process description
E = Emission rate
C = Control method

Figure 3.7.15 Schedule for installation of a fabric filter on a zinc smelting furnace for particulate pollutant control.



☐ Milestones

→ Activity and duration in weeks

MILESTONES		ELAPSED TIME (WEEKS)
1	Date of submittal of final control plan to appropriate agency.	4
2	Date of award of control device contract.	14
3	Date of initiation of on-site construction or installation of emission control equipment.	33
4	Date by which on-site construction or installation of emission control equipment is completed.	45
5	Date by which final compliance is achieved.	49

ACTIVITIES

Designation		Designation	
A-C	Preliminary investigation	K-L	Review and approval of assembly drawings
B-C	Source tests	L-M	Vendor prepares fabrication drawings
C-D	Evaluate control alternatives	M-N	Fabricate control device
D-E	Commit funds for total program	L-O	Prepare engineering drawings
E-F	Prepare preliminary control plan and compliance schedule for agency	O-P	Procure construction bids
F-G	Agency review and approval	P-Q	Evaluate construction bids
G-1	Finalize plans and specifications	Q-3	Award construction contract
1-H	Procure control device bids	3-N	On-site construction
H-I	Evaluate control device bids	N-R	Install control device
I-J	Award control device contract	R-4	Complete construction (system tie-in)
2-K	Vendor prepares assembly drawings	4-5	Startup, shakedown, preliminary source test

3.7.7 Magnesium Smelting

Process Description - Magnesium is smelted in steel pot furnaces with capacities ranging between 500 and 5000 pounds per batch. The raw material usually consists of scrap metal, magnesium shavings and turnings, and similar materials. The heat source is either natural gas, oil, or electric induction. A flux covers the surface of the molten metal since magnesium will burn in air at the pouring temperatures. The molten magnesium is usually cast by pouring it into molds and the molds are then annealed in ovens in an inert atmosphere.

Atmospheric Emissions - Particulates are the emissions of primary concern. During the first few seconds following the charging of the furnace, particulate may be emitted as a result of incomplete combustion of oils and other organic materials adhering to the scrap. Sub-micron metal oxides and chlorides can be emitted during the entire melting and refining stages.

Particulate emissions from pot furnaces are estimated to be approximately 4 pounds per ton.

Control Systems - Two types of control devices are in use, baghouses and high-energy wet scrubbers.

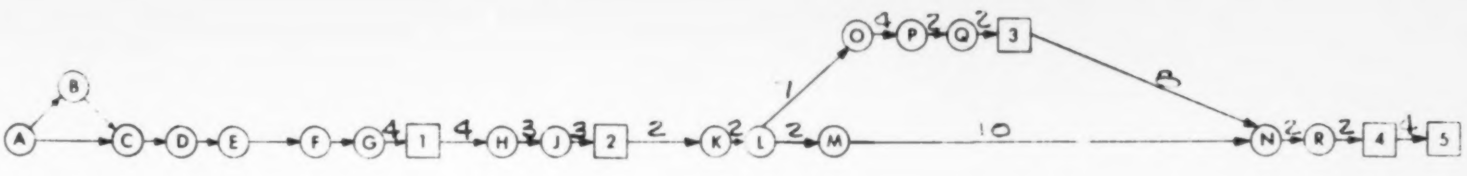
Compliance Schedules - Figures 3.7.16 and 3.7.17 illustrate expeditious schedules for installation of a fabric filter and a high-energy wet scrubber, respectively.

Sources of Additional Information

Source	Type of Information*
1) Exhaust Gases from Combustion and Industrial Processes NTIS Publication PB 204-861	P, C

* P = Process description
E = Emission rates
C = Control devices

Figure 3.7.16 Schedule for installation of a fabric filter on a magnesium smelting furnace for particulate pollutant control.



☐ = Milestones

$\xrightarrow{2}$ = Activity and duration in weeks

MILESTONES

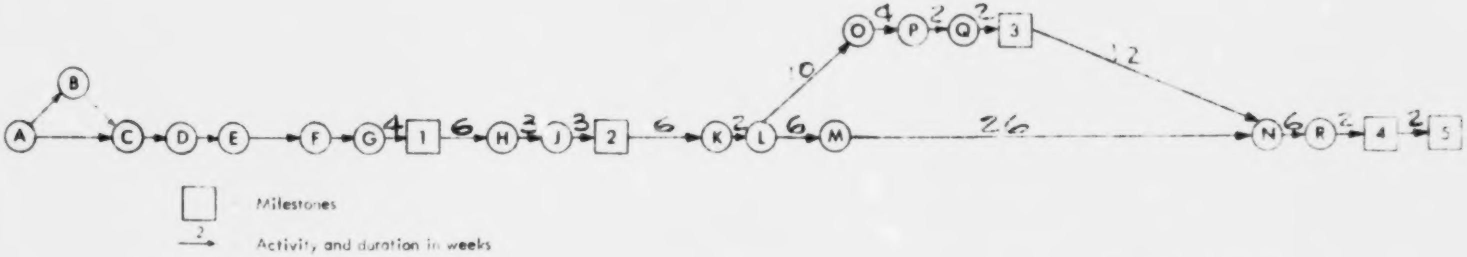
		ELAPSED TIME (WEEKS)
1	Date of submittal of final control plan to appropriate agency.	4
2	Date of award of control device contract.	14
3	Date of initiation of on-site construction or installation of emission control equipment.	33
4	Date by which on-site construction or installation of emission control equipment is completed.	45
5	Date by which final compliance is achieved.	49

ACTIVITIES

Designation	
A-C	Preliminary investigation
A-B	Source tests
C-D	Evaluate control alternatives
D-E	Commit funds for total program
E-F	Prepare preliminary control plan and compliance schedule for agency
F-G	Agency review and approval
G-1	Finalize plans and specifications
1-H	Procure control device bids
H-J	Evaluate control device bids
J-2	Award control device contract
2-K	Vendor prepares assembly drawings

Designation	
K-L	Review and approval of assembly drawings
L-M	Vendor prepares fabrication drawings
M-N	Fabricate control device
L-O	Prepare engineering drawings
O-P	Procure construction bids
P-Q	Evaluate construction bids
Q-3	Award construction contract
3-N	On-site construction
N-R	Install control device
R-4	Complete construction (system tie-in)
4-5	Startup, shakedown, preliminary source test

Figure 3.7.17 Schedule for installation of a wet scrubber system on a magnesium smelting furnace for particulate pollutant control.



MILESTONES

		ELAPSED TIME (WEEKS)
1	Date of submittal of final control plan to appropriate agency.	[illegible]
2	Date of award of control device contract.	16
3	Date of initiation of on-site construction or installation of emission control equipment.	42
4	Date by which on-site construction or installation of emission control equipment is completed.	64
5	Date by which final compliance is achieved.	66

ACTIVITIES

Designation	
A-C	Preliminary investigation
A-B	Source tests
C-D	Evaluate control alternatives
D-E	Commit funds for total program
E-F	Prepare preliminary control plan and compliance schedule for agency
F-G	Agency review and approval
G-1	Finalize plans and specifications
1-H	Procure control device bids
H-J	Evaluate control device bids
J-2	Award control device contract
2-K	Vendor prepares assembly drawings

Designation	
K-L	Review and approval of assembly drawings
L-M	Vendor prepares fabrication drawings
M-N	Fabricate control device
L-O	Prepare engineering drawings
O-P	Procure construction bids
P-Q	Evaluate construction bids
Q-3	Award construction contract
3-N	On-site construction
N-R	Install control device
R-4	Complete construction (system tie-in)
4-5	Startup, shakedown, preliminary source test

3.7.8 Core Making and Sand Handling

Process Description - Core making and sand handling operations are schematically illustrated in Figure 3.7.18. Cores are used in the molds to form the interior of hollow castings. The cores are prepared with binders, which usually require baking to develop the strength required to resist erosion and deformation when the mold is filled with molten metal. Several types of core ovens are in use, including shelf ovens, drawer ovens, portable-rack ovens, car ovens, and conveyor ovens. Each type is more suitable for one application than another, depending on such factors as maximum size or quantity of cores that can be handled.

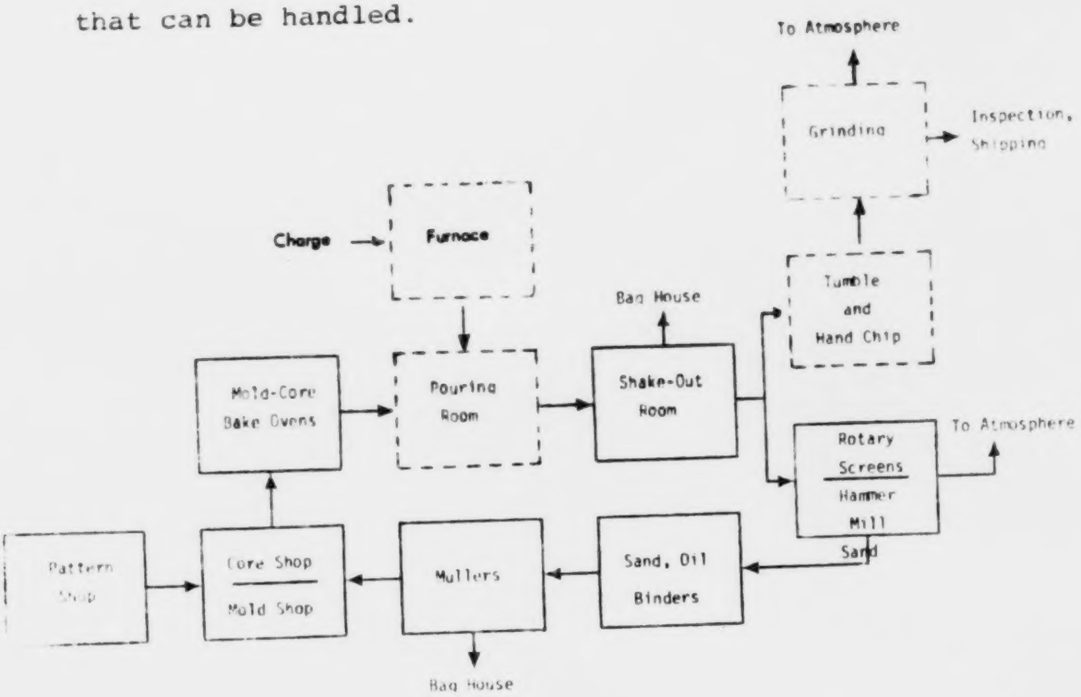

To Atmosphere
Grinding
Inspection, Shipping
Charge
Furnace
Bag House
Tumble and Hand Chip
Mold-Core Bake Ovens
Pouring Room
Shake-Out Room
Rotary Screens
Hammer Mill
To Atmosphere
Sand
Pattern Shop
Core Shop
Mold Shop
Mullers
Sand, Oil Binders
Bag House

Figure 3.7.18 Core making and sand handling

Atmospheric Emissions - Emissions from core making and sand handling operations are usually much less significant than those of other foundry operations. The core baking oven emissions consist primarily of condensed and gaseous hydrocarbons. Emission rates are highly variable, depending on binder composition and baking procedures. Odor may be a problem. Emissions from the sand handling system consist mainly of sand.

Control Systems - Emissions from core ovens can be controlled by afterburners, although most ovens are not controlled. Emissions from sand handling operations can be controlled by fabric filters.

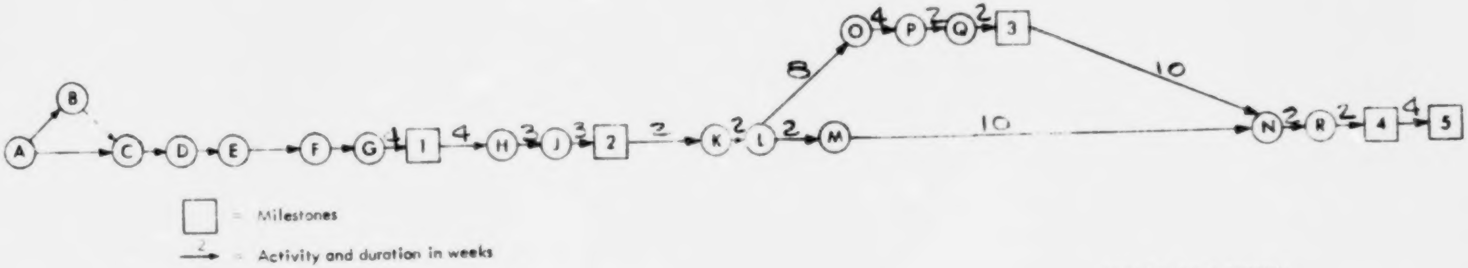
Compliance Schedules - Figures 3.7.19 and 3.7.20 illustrate expeditious schedules for installation of an afterburner or core ovens and a baghouse on sand handling operations, respectively.

Sources of Additional Information

Source	Type of Information*
1. Air Pollution Engineering Manual Public Health Service Publication No. 999-AP-40	P, E, C
2. Systems Analysis of Emissions and Emissions Control in the Iron Foundry Industry NTIS No. PB 198-348	P, E, C
3. Air Pollution Engineering Manual Public Health Service Publication No. 999-AP-40	P, E, C

* P = Process description
E = Emission rates
C = Control devices

Figure 3.7.19 Schedule for installation of an afterburner on a core baking oven for hydrocarbon emissions control.



MILESTONES

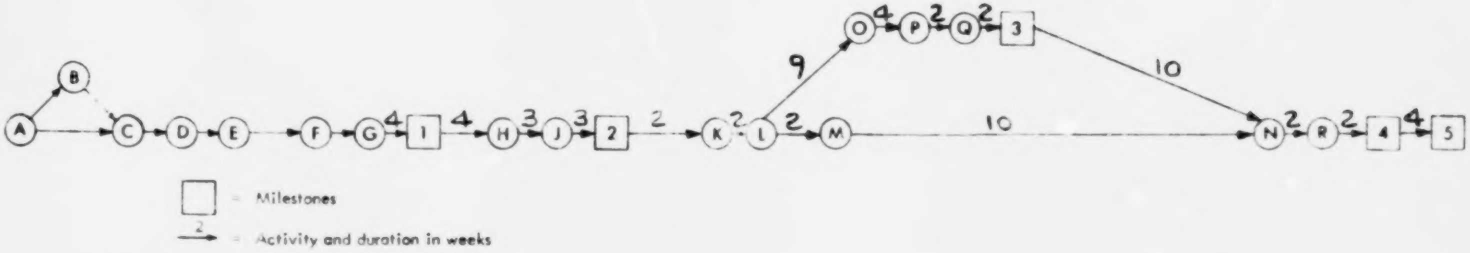
		ELAPSED TIME (WEEKS)
1	Date of submittal of final control plan to appropriate agency.	4
2	Date of award of control device contract.	14
3	Date of initiation of on-site construction or installation of emission control equipment	34
4	Date by which on-site construction or installation of emission control equipment is completed	48
5	Date by which final compliance is achieved.	52

ACTIVITIES

Designation	
A-C	Preliminary investigation
A-B	Source tests
C-D	Evaluate control alternatives
D-E	Commit funds for total program
E-F	Prepare preliminary control plan and compliance schedule for agency
F-G	Agency review and approval
G-1	Finalize plans and specifications
1-H	Procure control device bids
H-J	Evaluate control device bids
J-2	Award control device contract
2-K	Vendor prepares assembly drawings

Designation	
K-L	Review and approval of assembly drawings
L-M	Vendor prepares fabrication drawings
M-N	Fabricate control device
L-O	Prepare engineering drawings
O-P	Procure construction bids
P-Q	Evaluate construction bids
Q-3	Award construction contract
3-N	On-site construction
N-R	Install control device
R-4	Complete construction (system tie-in)
4-5	Startup, shakedown, preliminary source test

Figure 3.7.20 Schedule for installation of a fabric filter on a sand handling system for particulate pollutant control.



MILESTONES

		ELAPSED TIME (WEEKS)
1	Date of submittal of final control plan to appropriate agency.	4
2	Date of award of control device contract.	14
3	Date of initiation of on-site construction or installation of emission control equipment.	35
4	Date by which on-site construction or installation of emission control equipment is completed.	49
5	Date by which final compliance is achieved.	53

ACTIVITIES

Designation	
A-C	Preliminary investigation
A-B	Source tests
C-D	Evaluate control alternatives
D-E	Commit funds for total program
E-F	Prepare preliminary control plan and compliance schedule for agency
F-G	Agency review and approval
G-1	Finalize plans and specifications
1-H	Procure control device bids
H-J	Evaluate control device bids
J-2	Award control device contract
2-K	Vendor prepares assembly drawings

Designation	
K-L	Review and approval of assembly drawings
L-M	Vendor prepares fabrication drawings
M-N	Fabricate control device
L-O	Prepare engineering drawings
O-P	Procure construction bids
P-Q	Evaluate construction bids
Q-3	Award construction contract
3-N	On-site construction
N-R	Install control device
R-4	Complete construction (system tie-in)
4-5	Startup, shakedown, preliminary source test

3.8 Mineral Industries

3.8.1 Portland Cement

Process Description - Portland cement is manufactured by both dry and wet processes. Both processes include four major steps: quarrying and crushing, grinding and blending, clinker production through calcination, and finished grinding and packaging.

In the wet process, the wet ground material is pumped in slurry form to large mixing tanks, from which it is subsequently pumped to the kilns. In the dry process, the dry, ground raw material is conveyed to the storage bins and then fed to the kilns. In the initial section of the kiln, the ground material is heated and dried. As it progresses through the kiln it is calcined and heated until it fuses, forming clinker. The clinker is discharged from the kiln, cooled, and ground to produce the finished cement.

A simplified flow diagram of cement plant operation is shown in Figure 3.8.1.

Atmospheric Emissions - More than a dozen process areas in a typical cement plant require effective emission control. These processes encompass widely varying conditions of temperature, dust load, air volumes, and particle sizes, and all require high-efficiency collection systems.

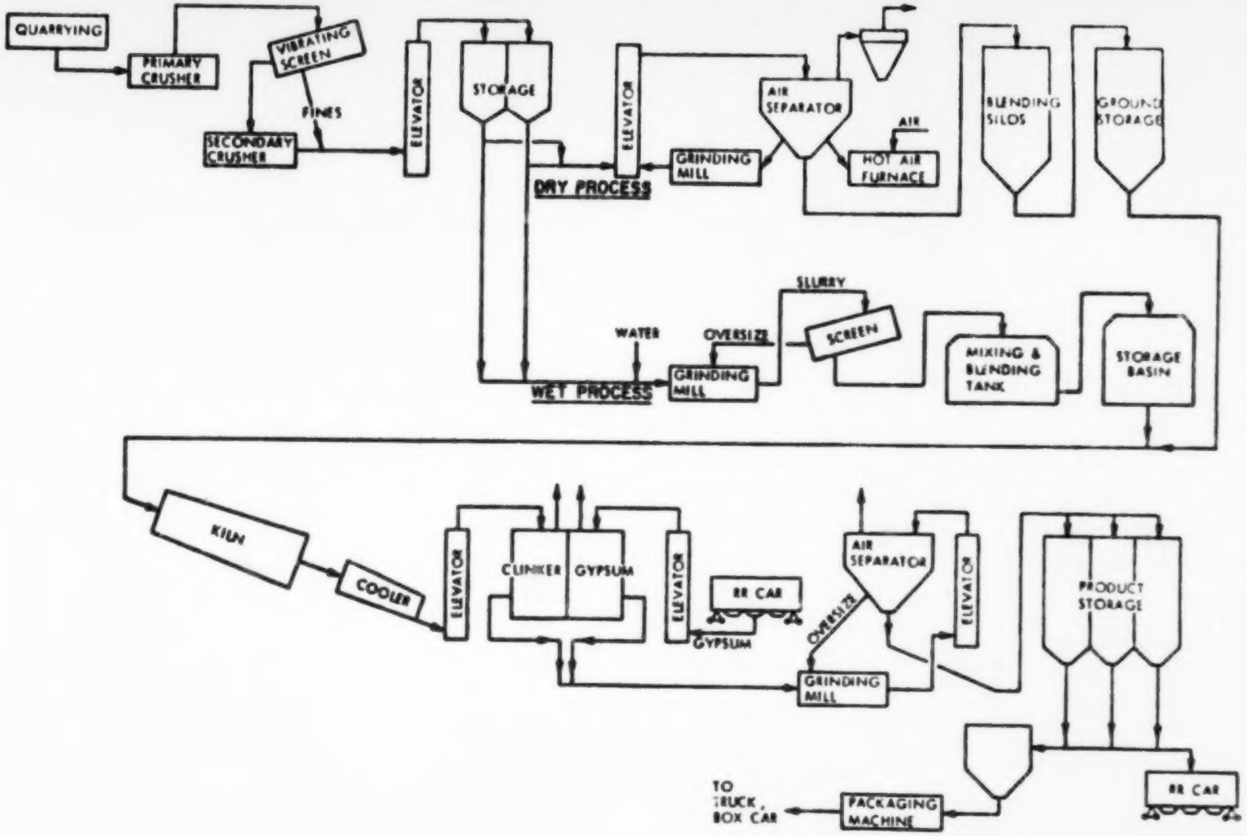

QUARRYING
PRIMARY CRUSHER
VIBRATING SCREEN
FINES
SECONDARY CRUSHER
ELEVATOR
STORAGE
DRY PROCESS
ELEVATOR
GRINDING MILL
AIR SEPARATOR
AIR
HOT AIR FURNACE
BLENDING SILOS
GROUND STORAGE
WATER
OVERSIZE
SLURRY
SCREEN
WET PROCESS
GRINDING MILL
MIXING & BLENDING TANK
STORAGE BASIN
KILN
COOLER
ELEVATOR
CLINKER
GYPSUM
ELEVATOR
RR CAR
GYPSUM
AIR SEPARATOR
OVERSIZE
ELEVATOR
GRINDING MILL
PRODUCT STORAGE
RR CAR
PACKAGING MACHINE
TO TRUCK, BOX CAR

Figure 3.8.1 Cement manufacture.

The major source of particulate emission from both the dry and wet processes is the calcining kiln. Dust is generated by the tumbling action within the kiln as well as by volatilization of components during calcination. Secondary in importance as sources of particulate emission are the clinker cooler and the grinders.

Particulate emissions from the calcining kiln range between 15 and 55 pounds per ton for the wet process, and 35 and 75 pounds per ton for the dry process.

Control Systems - Both fabric filters and electrostatic precipitators are used to control emissions from cement kilns. Fabric filters are more commonly used on dry process systems because of their higher collection efficiencies and relative insensitivity to variations in process operating conditions; they are also used occasionally on wet process sytems. Fabric filters are also used to control emissions from various transferring and handling operations. Electrostatic precipitators are used primarily to control emissions from kilns on wet process plants.

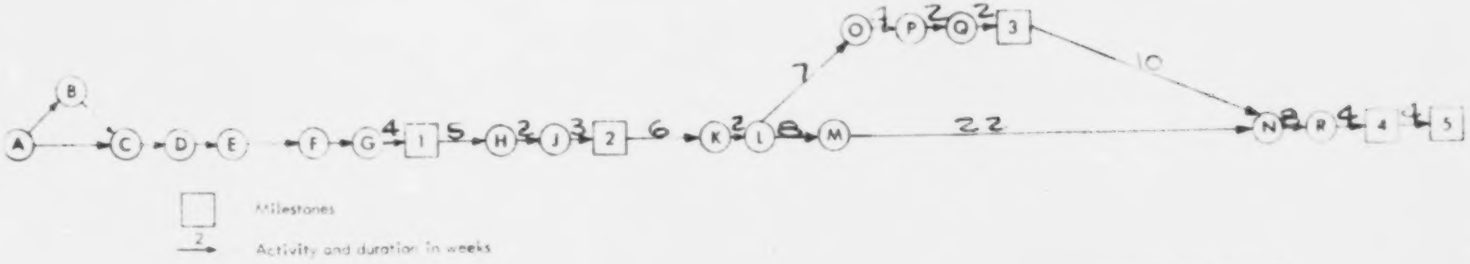
Compliance Schedules - Figures 3.8.2 and 3.8.3 illustrate expeditious schedules for installation of a fabric filter and an electrostatic precipitator on a cement kiln.

Sources of Additional Information

Source	Type of Information*
1) Atmospheric Emission from the Manufacture of Portland Cement. Public Health Service Publication No. 999-AP-17	P
2) Handbook of Emissions, Effluents, and Control Practices for Stationary Particulate Pollution Sources. NTIS No. PB 203-522	P,E,C
3) A Manual of Electrostatic Precipitator Technology, Part II - Application Areas. NTIS No. PB 196-381	C
4) Background Information for Proposed New-Source Performance Standards: Steam Generators, Incinerators, Portland Cement Plants, Nitric Acid Plants and Sulfuric Acid Plants NTIS No. PB 202-459	C
5) Air Pollution Aspects of Emission Sources: Cement Manufacturing NTIS No. PB 200-080	E, C

* P = Process description
E = Emission rates
C = Control devices

Figure 3.3.2 Compliance schedule for installation of a fabric filter on a cement kiln for particulate pollutant control.



MILESTONES

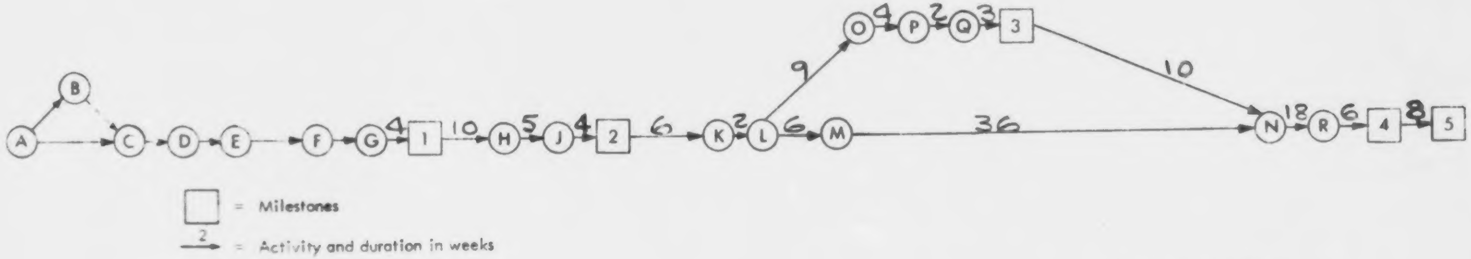
		ELAPSED TIME (WEEKS)
1	Date of submittal of final control plan to appropriate agency	4
2	Date of award of control device contract.	14
3	Date of initiation of on-site construction or installation of emission control equipment	37
4	Date by which on-site construction or installation of emission control equipment is completed.	64
5	Date by which final compliance is achieved.	68

ACTIVITIES

Designation	
A-C	Preliminary investigation
A-B	Source tests
C-D	Evaluate control alternatives
D-E	Commit funds for total program
E-F	Prepare preliminary control plan and compliance schedule for agency
F-G	Agency review and approval
G-1	Finalize plans and specifications
1-H	Procure control device bids
H-J	Evaluate control device bids
J-2	Award control device contract
2-K	Vendor prepares assembly drawings

Designation	
K-L	Review and approval of assembly drawings
L-M	Vendor prepares fabrication drawings
M-N	Fabricate control device
L-O	Prepare engineering drawings
O-P	Procure construction bids
P-Q	Evaluate construction bids
Q-3	Award construction contract
3-N	On-site construction
N-R	Install control device
R-4	Complete construction (system tie-in)
4-5	Startup, shakedown, preliminary source test

Figure 3.8.3 Compliance schedule for installation of an electrostatic precipitator on a cement kiln for particulate pollutant control.



MILESTONES		ELAPSED TIME (WEEKS)
1	Date of submittal of final control plan to appropriate agency.	4
2	Date of award of control device contract.	23
3	Date of initiation of on-site construction or installation of emission control equipment.	49
4	Date by which on-site construction or installation of emission control equipment is completed.	97
5	Date by which final compliance is achieved.	105

ACTIVITIES

Designation	
A-C	Preliminary investigation
A-B	Source tests
C-D	Evaluate control alternatives
D-E	Commit funds for total program
E-F	Prepare preliminary control plan and compliance schedule for agency
F-G	Agency review and approval
G-1	Finalize plans and specifications
1-H	Procure control device bids
H-J	Evaluate control device bids
J-2	Award control device contract
2-K	Vendor prepares assembly drawings

Designation	
K-L	Review and approval of assembly drawings
L-M	Vendor prepares fabrication drawings
M-N	Fabricate control device
L-O	Prepare engineering drawings
O-P	Procure construction bids
P-Q	Evaluate construction bids
Q-3	Award construction contract
3-N	On-site construction
N-R	Install control device
R-4	Complete construction (system tie-in)
4-5	Startup, shakedown, preliminary source test

3.8.2 Lime

Process Description - The principal raw materials for lime manufacture are calcium carbonate (limestone) or calcium-magnesium carbonate (dolomite or dolomitic limestone). The limestone or dolomite is heated in either vertical or horizontal kilns to decompose the carbonate, releasing CO_2 and leaving calcium and magnesium oxide as the products. During the heating process, moisture and volatile organic matter are also driven off. Figure 3.8.4 illustrates the lime manufacturing process.

Atmospheric Emissions - The major source of particulate emission is the calcining kiln. Emissions vary with the type of kiln and composition of the limestone. Vertical kilns emit less than rotary kilns because of the larger size of the limestone charged, the lower gas velocities, and the smaller amount of attrition. In rotary kilns, abrasion of limestone produces dust, which is entrained by the high velocity combustion gases. Particulate emission from a rotary kiln, if uncontrolled, is about 200 pounds per ton of lime processed. Emissions from vertical kilns are approximately 8 pounds per ton.

Control Systems - Most rotary kilns incorporate a settling chamber or cyclone precleaner to remove coarse particles. Wet scrubbers and fabric filters using glass or Nomex fabric are used for high efficiency particulate collection. Electrostatic precipitators

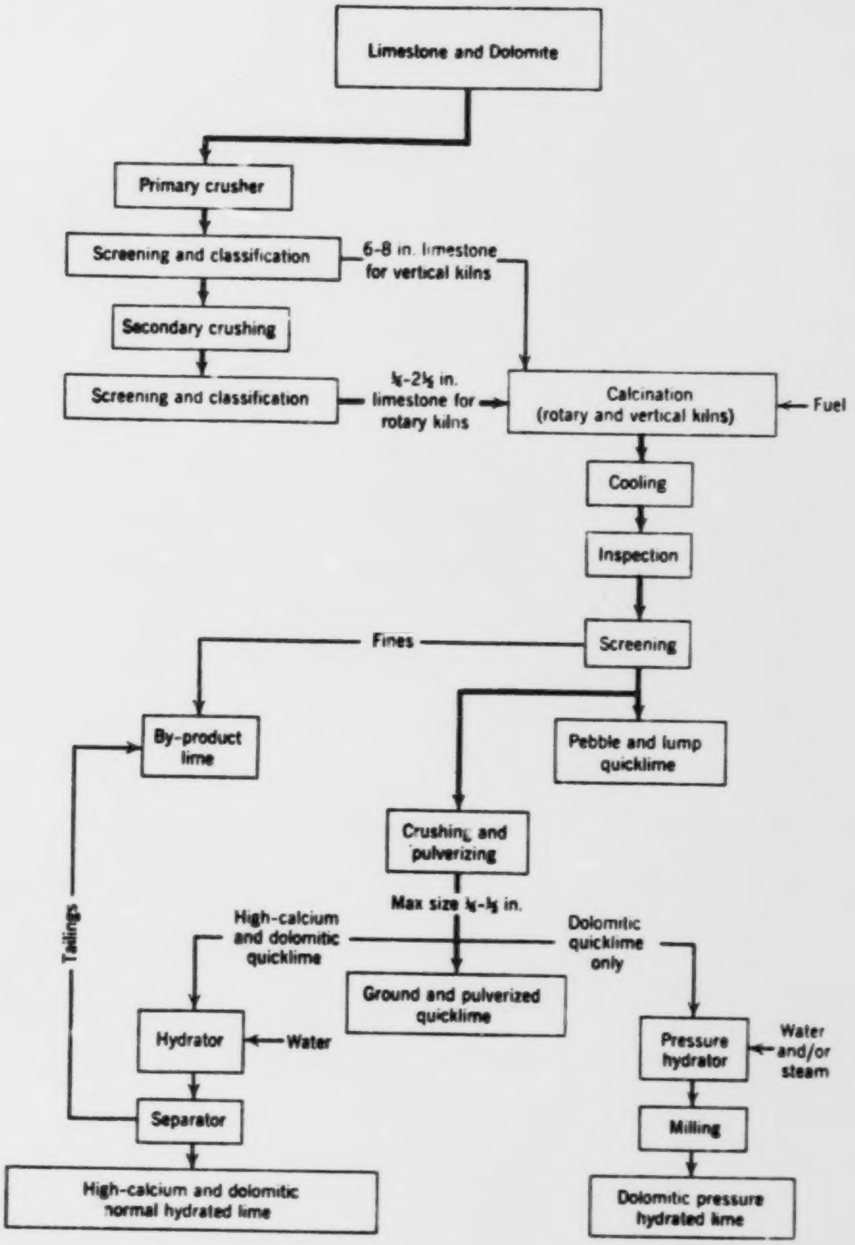

Limestone and Dolomite
Primary crusher
Screening and classification
6-8 in. limestone for vertical kilns
Secondary crushing
Screening and classification
¼-2½ in. limestone for rotary kilns
Calcination (rotary and vertical kilns)
Fuel
Cooling
Inspection
Screening
Fines
By-product lime
Pebble and lump quicklime
Crushing and pulverizing
Max size ¼-½ in.
High-calcium and dolomitic quicklime
Dolomitic quicklime only
Ground and pulverized quicklime
Tailings
Hydrator
Water
Separator
High-calcium and dolomitic normal hydrated lime
Pressure hydrator
Water and/or steam
Milling
Dolomitic pressure hydrated lime

Figure 3.8.4 **Manufacture** of lime and limestone products

(Source: Kirk-Othmer. Encyclopedia of Chemical Technology) are also used, but not as frequently as fabric filters or wet scrubbers.

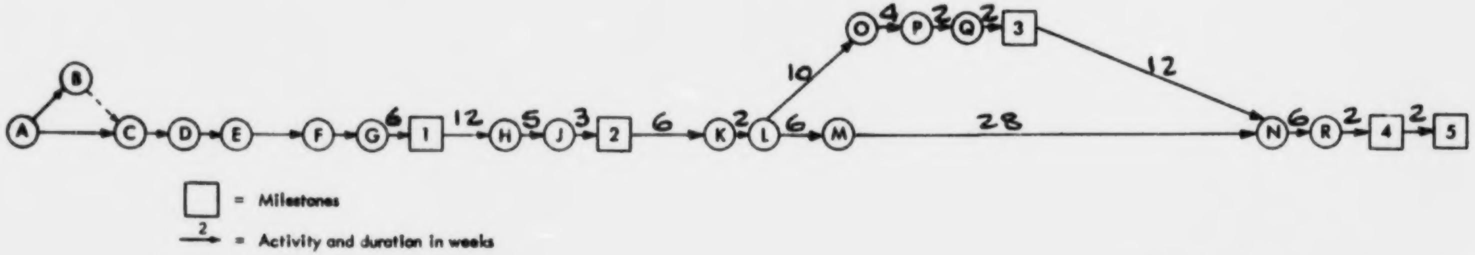
Compliance Schedules - Figures 3.8.5 and 3.8.6 illustrate expeditious schedules for installation of a wet scrubber and a fabric filter on lime kilns.

Sources of Additional Information

Source	Type of Information*
1) Handbook of Emissions, Effluents, and Control Practices for Stationary Particulate Pollution Sources. NTIS No. PB 203-522	P,E
2) Study of Technical and Cost Information for Gas Cleaning in the Lime and Secondary Non-Ferrous Metallurgical Industries. NTIS No. PB 198-137	C

* P = Process description
E = Emission rates
C = Control devices

Figure 3.8.5 Schedule for installation of wet scrubber on lime manufacturing operation for particulate pollutant control.

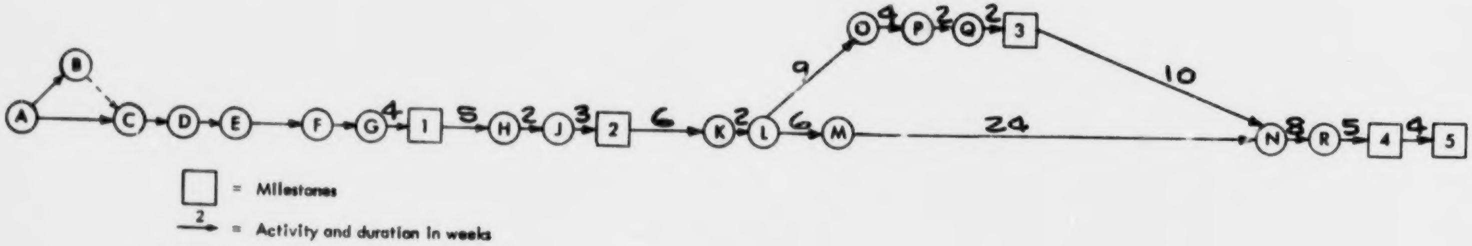


MILESTONES		ELAPSED TIME (WEEKS)
1	Date of submittal of final control plan to appropriate agency.	6
2	Date of award of control device contract.	26
3	Date of initiation of on-site construction or installation of emission control equipment.	52
4	Date by which on-site construction or installation of emission control equipment is completed.	74
5	Date by which final compliance is achieved.	76

ACTIVITIES

Designation		Designation	
A-C	Preliminary investigation	K-L	Review and approval of assembly drawings
A-B	Source tests	L-M	Vendor prepares fabrication drawings
C-D	Evaluate control alternatives	M-N	Fabricate control device
D-E	Commit funds for total program	L-O	Prepare engineering drawings
E-F	Prepare preliminary control plan and compliance schedule for agency	O-P	Procure construction bids
F-G	Agency review and approval	P-Q	Evaluate construction bids
G-1	Finalize plans and specifications	Q-3	Award construction contract
1-H	Procure control device bids	3-N	On-site construction
H-J	Evaluate control device bids	N-R	Install control device
J-2	Award control device contract	R-4	Complete construction (system tie-in)
2-K	Vendor prepares assembly drawings	4-5	Startup, shakedown, preliminary source test

Figure 3.8.6 Schedule for installation of fabric filter on lime manufacturing operation for particulate pollutant control.



MILESTONES

		ELAPSED TIME (WEEKS)
1	Date of submittal of final control plan to appropriate agency.	4
2	Date of award of control device contract.	14
3	Date of initiation of on-site construction or installation of emission control equipment.	39
4	Date by which on-site construction or installation of emission control equipment is completed.	65
5	Date by which final compliance is achieved.	69

ACTIVITIES

Designation	
A-C	Preliminary investigation
A-B	Source tests
C-D	Evaluate control alternatives
D-E	Commit funds for total program
E-F	Prepare preliminary control plan and compliance schedule for agency
F-G	Agency review and approval
G-1	Finalize plans and specifications
1-H	Procure control device bids
H-J	Evaluate control device bids
J-2	Award control device contract
2-K	Vendor prepares assembly drawings

Designation	
K-L	Review and approval of assembly drawings
L-M	Vendor prepares fabrication drawings
M-N	Fabricate control device
L-O	Prepare engineering drawings
O-P	Procure construction bids
P-Q	Evaluate construction bids
Q-3	Award construction contract
3-N	On-site construction
N-R	Install control device
R-4	Complete construction (system tie-in)
4-5	Startup, shakedown, preliminary source test

3.8.3 Phosphate Rock

Process Description - Phosphate rock processing involves beneficiating the ore to reduce impurities, drying to remove moisture, and grinding to improve its reactivity during subsequent processing steps, such as its reaction with sulfuric acid to produce phosphoric acid. A simplified phosphate rock processing operation is shown in Figure 3.8.7.

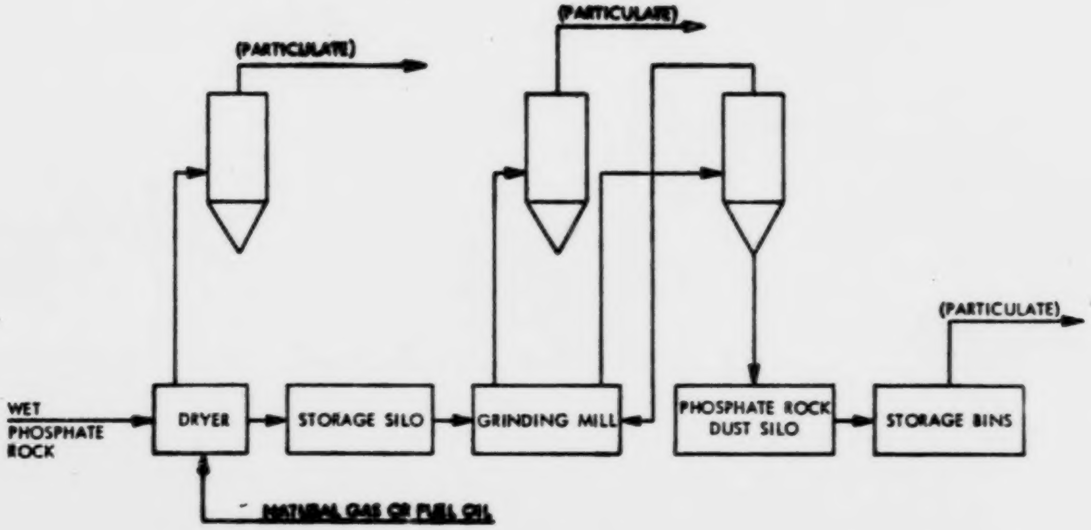

(PARTICULATE)
(PARTICULATE)
(PARTICULATE)
WET PHOSPHATE ROCK
DRYER
STORAGE SILO
GRINDING MILL
PHOSPHATE ROCK DUST SILO
STORAGE BINS
NATURAL GAS OR FUEL OIL

Figure 3.8.7 Phosphate rock processing.

Atmospheric Emissions - The major sources of particulate emissions are the grinding and drying operation; open storage piles can cause significant emissions of fugitive dust.

Emissions from uncontrolled phosphate rock processing vary from approximately 2 pounds per ton of rock for transfer and conveying systems to 40 pounds per ton for open storage piles. Drying and grinding operations emit 15 to 20 pounds per ton of rock processed.

Control Systems - Fabric filters are the most commonly used high-efficiency control devices, operating with collection efficiencies in excess of 99 percent.

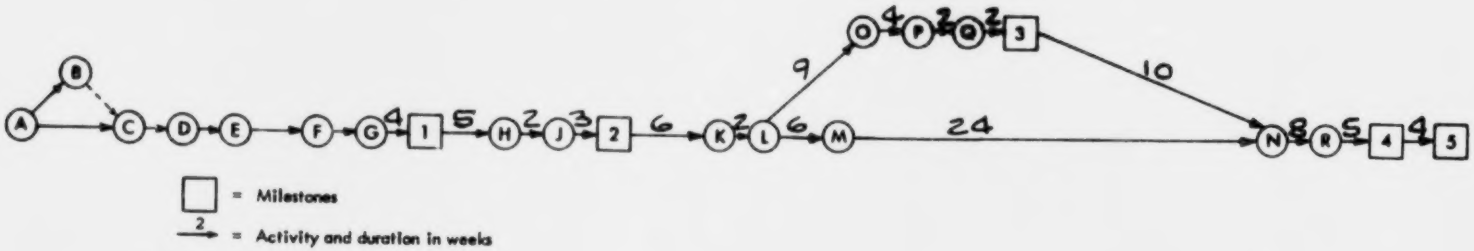
Compliance Schedules - Figure 3.8.8 illustrates an expeditious schedule for installation of a fabric filter on phosphate rock processing operations.

Sources of Additional Information

Source	Type of Information*
1) Handbook of Emissions, Effluents, and Control Practices for Stationary Particulate Pollution Sources. NTIS No. PB 203-522	P, E, C
2) Kirk-Othmer, Encyclopedia of Chemical Technology (2nd Edition) Interscience Publishers New York, New York	P
3) Air Pollution Control Field Operations Manual APTD Publication No. 1164	P

* P = Process description
E = Emission rates
C = Control devices

Figure 3.8.8 Schedule for installation of fabric filter on phosphate rock processing operation for particulate pollutant control.



MILESTONES

		ELAPSED TIME (WEEKS)
1	Date of submittal of final control plan to appropriate agency.	4
2	Date of award of control device contract.	14
3	Date of initiation of on-site construction or installation of emission control equipment.	39
4	Date by which on-site construction or installation of emission control equipment is completed.	65
5	Date by which final compliance is achieved.	69

ACTIVITIES

Designation		Designation	
A-C	Preliminary investigation	K-L	Review and approval of assembly drawings
A-B	Source tests	L-M	Vendor prepares fabrication drawings
C-D	Evaluate control alternatives	M-N	Fabricate control device
D-E	Commit funds for total program	L-O	Prepare engineering drawings
E-F	Prepare preliminary control plan and compliance schedule for agency	O-P	Procure construction bids
F-G	Agency review and approval	P-Q	Evaluate construction bids
G-1	Finalize plans and specifications	Q-3	Award construction contract
1-H	Procure control device bids	3-N	On-site construction
H-J	Evaluate control device bids	N-R	Install control device
J-2	Award control device contract	R-4	Complete construction (system tie-in)
2-K	Vendor prepares assembly drawings	4-5	Startup, shakedown, preliminary source test

3.8.4 Glass

Process Description - At a typical glass plant, glass sand, soda ash, limestone, cullet (broken glass), and minor ingredients are batch weighed, mixed, and charged to the glass furnace. In the furnace, the dry mixture blends with the molten glass; the batch is mixed for homogeneity and heat conditioned to eliminate stones.

The molten glass from the furnace is partially cooled and worked on forming machines in a variety of methods including pressing, drawing, rolling, casting, and blowing in molds. The glass articles are immediately conveyed to gas fired or electrically heated annealing ovens which heat-treat to remove strains developed during molding.

A flow diagram of a soda-lime glass plant is shown in Figure 3.8.9.

Atmospheric Emissions - Particulates can be emitted during the unloading and transferring of raw materials. Emissions from the glass furnace, however, present the most serious problem. The rate of particulate emission from the furnaces varies considerably, depending upon the composition of the glass produced and on the furnace design and operating conditions. Container glass and plate glass, both soda-lime glasses, generally present less of an

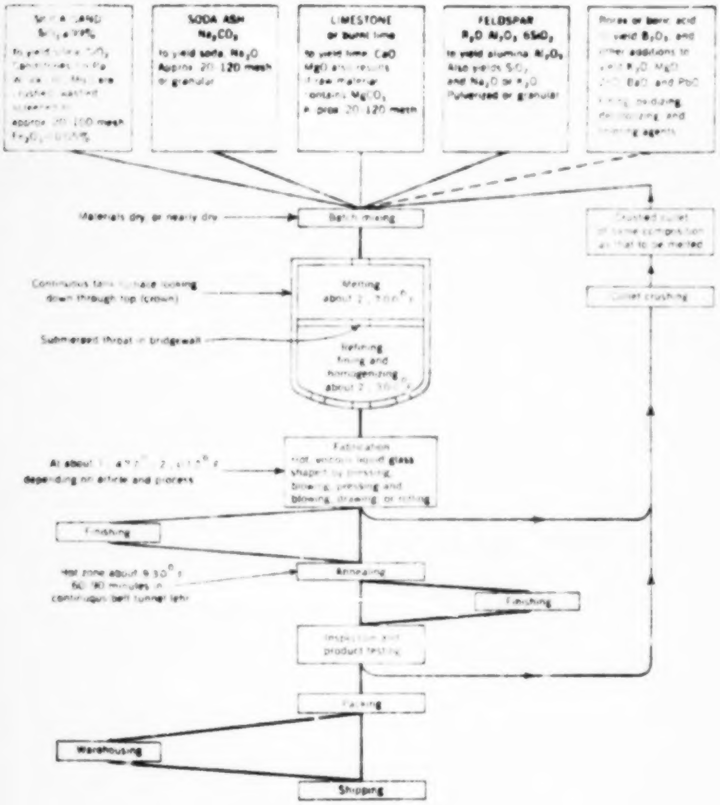

SILICA SAND
SODA ASH
Na_2CO_3
to yield soda Na_2O
Approx. 20-120 mesh
or granular
LIMESTONE
or burnt lime
to yield lime CaO
MgO also results
if raw material
contains $MgCO_3$
Approx. 20-120 mesh
FELDSPAR
$R_2O\ Al_2O_3\ 6SiO_2$
to yield alumina Al_2O_3
Also yields SiO_2
and Na_2O or K_2O
Pulverized or granular
Borax or boric acid
to yield B_2O_3, and
other additions to
yield K_2O, MgO,
ZnO, BaO, and PbO
fining, oxidizing,
decolorizing, and
coloring agents
Materials dry, or nearly dry
Batch mixing
Crushed cullet
of same composition
as that to be melted
Cullet crushing
Continuous tank furnace looking
down through top (crown)
Melting
Submerged throat in bridgewall
Refining
fining and
homogenizing
Fabrication
hot, viscous liquid glass
shaped by pressing,
blowing, pressing and
blowing, drawing, or rolling
depending on article and process
Finishing
Annealing
60-90 minutes in
continuous belt tunnel lehr
Finishing
Inspection and
product testing
Packing
Warehousing
Shipping

Figure 3.8.9 Soda-lime glass manufacture.

emission problem than specialty glasses. Particulate emissions result both from entrainment of batch constituents in the combustion air and from vaporization of certain volatile components in the melt. The volatile constituents subsequently condense to form particulates. Sulfates, fluorides, and borates are common batch constituents causing volatilization. The great variety of compounds used to produce the hundreds of specialty glasses can create substantial emissions problems, including the potential for emitting hazardous air pollutants.

Emissions from container-glass forming operations are due to the volatilization of the mold coating compounds, which creates a constant haze in the vicinity of the glass forming machine. Emissions from annealing ovens are negligible.

Control Systems - Fugitive dust emissions from unloading of raw materials can be effectively controlled by use of choked feeding and proper enclosures. Vent filters can be used on bin filling and conveying operations. Fabric filters can be used on mixers and weigh hoppers.

Only a few continuously operating control devices are used on glass furnaces. The most acceptable systems currently used are fabric filters and wet scrubbers. High-energy venturi scrubbers are capable of 95 plus percent collection efficiency but require pressure drop of approximately 50 inches of water.

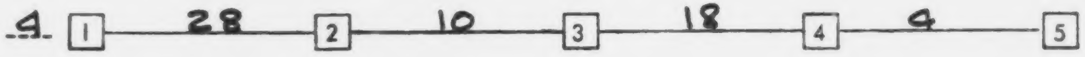
Baghouses have shown particulate collection efficiencies higher than 99 percent, but bag failures due to acid gases and high temperatures are a problem. On tableware and opal glass furnaces, fabric filters have proved effective.

Wherever possible, many soda-lime glass plants are changing batch compositions to reduce emissions and comply with emission regulations. Volatilized emissions are lowered by elimination or reduction of various refining agents such as sulfates. Also, the fluoride content of the batch in many plants has been reduced or eliminated to minimize fluoride emissions.

Electric furnaces offer a much lower emissions potential than gas-or oil-fired furnaces. Several plants have replaced existing furnaces with electric furnaces to meet emission regulations; however, use of electric furnaces in lieu of installing control devices is limited to those facilities where the annualized operating costs would make this economically feasible and the batch composition is such that emissions would be reduced sufficiently to meet emission regulations.

Compliance Schedules - Figures 3.8.10 and 3.8.11 illustrate expeditious schedules for installation of a fabric filter and a high-energy venturi scrubber. Because of the limited operating experience of these control devices on glass furnaces, these schedules should be considered as only rough guidelines.

Figure 3.8.10 Schedule for installation of a custom-designed fabric filter on a glass furnace for particulate pollutant control.

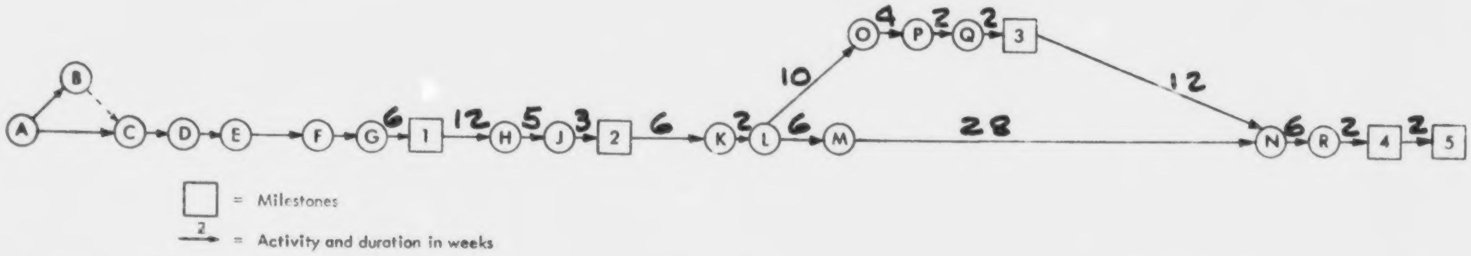


MILESTONES		ELAPSED TIME (WEEKS)
1	Date of submittal of final control plan to appropriate agency.	4
2	Date of award of control device contract.	32
3	Date of initiation of on-site construction or installation of emission control equipment.	42
4	Date by which on-site construction of emission control equipment is completed.	60
5	Date by which final compliance is achieved.	64

ACTIVITIES

DESIGNATIONS	
1 - 2	Preparation of detailed engineering and fabrication drawings, equipment specifications, construction bid documents and award of construction contract.
2 - 3	Equipment fabrication and delivery of structural components to site.
3 - 4	Delivery of remaining equipment and completion of construction including process tie in.
4 - 5	Equipment start up and source testing.

Figure 3.8.11 Schedule for installation of high-energy venturi scrubber on glass furnace for particulate pollutant control.



MILESTONES		ELAPSED TIME (WEEKS)
1	Date of submittal of final control plan to appropriate agency.	6
2	Date of award of control device contract.	26
3	Date of initiation of on-site construction or installation of emission control equipment.	52
4	Date by which on-site construction or installation of emission control equipment is completed.	74
5	Date by which final compliance is achieved.	76

ACTIVITIES

Designation		Designation	
A-C	Preliminary investigation	K-L	Review and approval of assembly drawings
A-B	Source tests	L-M	Vendor prepares fabrication drawings
C-D	Evaluate control alternatives	M-N	Fabricate control device
D-E	Commit funds for total program	L-O	Prepare engineering drawings
E-F	Prepare preliminary control plan and compliance schedule for agency	O-P	Procure construction bids
F-G	Agency review and approval	P-Q	Evaluate construction bids
G-1	Finalize plans and specifications	Q-3	Award construction contract
1-H	Procure control device bids	3-N	On-site construction
H-J	Evaluate control device bids	N-R	Install control device
J-2	Award control device contract	R-4	Complete construction (system tie-in)
2-K	Vendor prepares assembly drawings	4-5	Startup, shakedown, preliminary source test

Sources of Additional Information

Source	Type of Information*
1) Air Pollution Engineering Manual. PHS Publication No. 999-AP-40	P,E,C
2) Stockham, John D. The Composition of Glass Furnace Emissions. Journal of the Air Pollution Control Association, November 1971 Vol. 1, No. 11, page 713-715	E
3) Kirk-Othmer, Encyclopedia of Chemical Technology, Vol. 10, 2nd Ed., 1966	P

* P = Process description
E = Emission rates
C = Control devices

3.8.5 Fiber Glass

Process Description - The manufacture of fiber glass consists of melting various raw materials to form molten glass, drawing the glass into fibers, and coating the fibers with an organic material (the binder).

The processes, emissions, and control methods for the raw material handling operations and the glass melting furnace are similar to those described in Section 3.8.4.

Glass wool is formed by feeding molten glass through platinum bushings to form fine fibers. The fibers are sprayed with binders, cured at 400 to 500°F, air-cooled, and cut to proper size. Figure 3.8.12 illustrates the overall operation.

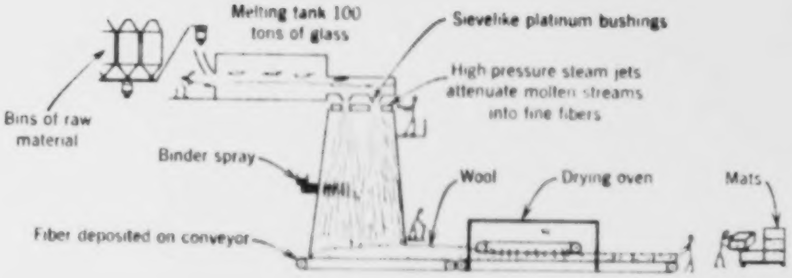

Melting tank 100 tons of glass
Sievelike platinum bushings
High pressure steam jets attenuate molten streams into fine fibers
Bins of raw material
Binder spray
Wool
Drying oven
Mats
Fiber deposited on conveyor

Figure 3.8.12 Fiber glass production

(Source: Kirk-Othmer. Encyclopedia of Chemical Technology)

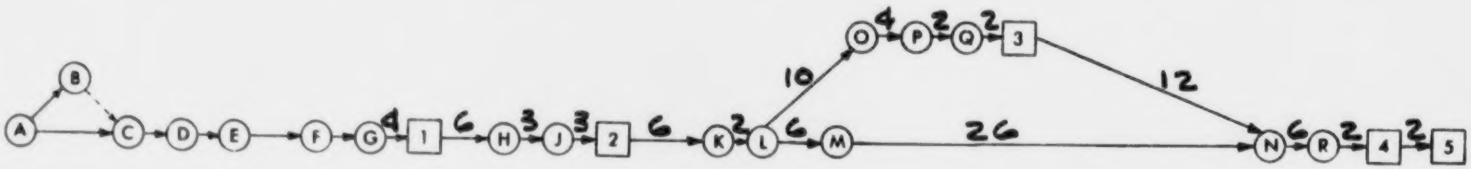
Atmospheric Emissions - The spraying resins on the glass fiber in the forming operation create a substantial volatile emissions problem. Components in the resin are driven off when contacting the hot fibers and subsequently condense to form fine particulates. The emission rate is increased by use of very fine binder sprays and binders with a high percentage of volatile components.

The curing ovens also emit volatile components from the binder, which condense upon cooling to create visible emissions. Oven temperature and binder composition affect the emission rate.

Control Systems - The High-Energy Air Filter device (HEAF) is the most widely used emission control method for forming lines and curing ovens. The unit usually requires pressure drops in excess of 30 inches water gauge to operate satisfactorily. High-energy wet scrubbers and afterburners have also been used to control emissions.

Compliance Schedules - Figures 3.8.13, 3.8.14, and 3.8.15 illustrate expeditious schedules for installation of a high-energy wet scrubber, a HEAF unit, and an afterburner on forming line and curing oven emission sources.

Figure 3.8.13 Schedule for installation of a high-energy wet scrubber on fiber glass forming and curing operations for particulate pollutant control.



☐ = Milestones

$\xrightarrow{2}$ = Activity and duration in weeks

MILESTONES

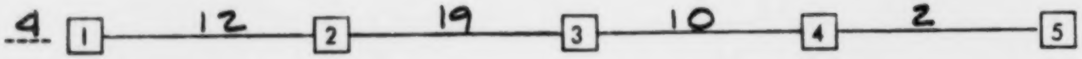
		ELAPSED TIME (WEEKS)
1	Date of submittal of final control plan to appropriate agency.	4
2	Date of award of control device contract.	16
3	Date of initiation of on-site construction or installation of emission control equipment.	42
4	Date by which on-site construction or installation of emission control equipment is completed.	64
5	Date by which final compliance is achieved.	66

ACTIVITIES

Designation	
A-C	Preliminary investigation
A-B	Source tests
C-D	Evaluate control alternatives
D-F	Commit funds for total program
E-F	Prepare preliminary control plan and compliance schedule for agency
F-G	Agency review and approval
G-1	Finalize plans and specifications
1-H	Procure control device bids
H-J	Evaluate control device bids
J-2	Award control device contract
2-K	Vendor prepares assembly drawings

Designation	
K-L	Review and approval of assembly drawings
L-M	Vendor prepares fabrication drawings
M-N	Fabricate control device
L-O	Prepare engineering drawings
O-P	Procure construction bids
P-Q	Evaluate construction bids
Q-3	Award construction contract
3-N	On-site construction
N-R	Install control device
R-4	Complete construction (system tie-in)
4-5	Startup, shakedown, preliminary source test

Figure 3.8.14 Schedule for installation of a high-energy air filter (HEAF) unit on fiber glass forming and curing operations for particulate pollutant control.

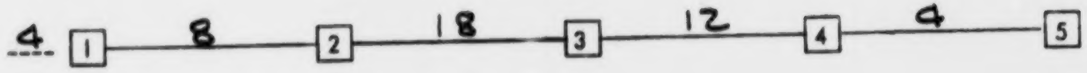


MILESTONES		ELAPSED TIME (WEEKS)
1	Date of submittal of final control plan to appropriate agency.	9
2	Date of award of control device contract.	16
3	Date of initiation of on-site construction or installation of emission control equipment.	35
4	Date by which on-site construction of emission control equipment is completed.	45
5	Date by which final compliance is achieved.	47

ACTIVITIES

DESIGNATIONS	
1 - 2	Preparation of detailed engineering and fabrication drawings, equipment specifications, construction bid documents and award of construction contract.
2 - 3	Equipment fabrication and delivery of structural components to site.
3 - 4	Delivery of remaining equipment and completion of construction including process tie in.
4 - 5	Equipment start up and source testing.

Figure 3.8.15 Schedule for installation of an afterburner on fiber glass forming and curing operations for particulate pollutant control.



MILESTONES		ELAPSED TIME (WEEKS)
1	Date of submittal of final control plan to appropriate agency.	4
2	Date of award of control device contract.	12
3	Date of initiation of on-site construction or installation of emission control equipment.	30
4	Date by which on-site construction of emission control equipment is completed.	42
5	Date by which final compliance is achieved.	46

ACTIVITIES

DESIGNATIONS	
1 - 2	Preparation of detailed engineering and fabrication drawings, equipment specifications, construction bid documents and award of construction contract.
2 - 3	Equipment fabrication and delivery of structural components to site.
3 - 4	Delivery of remaining equipment and completion of construction including process tie in.
4 - 5	Equipment start up and source testing.

Sources of Additional Information

Source	Type of Information*
1) Kirk-Othmer, Encyclopedia of Chemical Technology. Vol. 10, 2nd Ed. 1966	P
2) Air Pollution Engineering Manual. PHS Publication No. 999-AP-40	P,E,C

* P = Process description
E = Emission rates
C = Control devices

3.8.6 Asphalt Batching

Process Description - Asphalt batch processing consists of drying and heating various aggregates, screening, proportioning, weighing, and then mixing the hot dry aggregate with molten asphalt. Both continuous and batch mix plants are in operation. These plants are very similar except for the final weighing and mixing steps, which in the latter case is done on a batch basis. Asphalt batch plants range in size between 50 and 300 tons per hour.

As shown in Figure 3.8.16, aggregate consisting of crushed stone, slag, and gravel or sand is sized and loaded in a storage hopper. From the hopper it flows into the elevated end of a rotary dryer. A gas or oil burner supplies heat directly at the lower or discharge end of the dryer. After drying, the hot aggregate is screened and mixed with hot asphalt.

Atmospheric Emissions - Conveyor belt and bucket elevator transfer points, bin loading, and screening operations can be sources of fugitive dust emission. The combustion gas stream from the rotary dryer, however, is the primary source of particulate emissions. This stream usually passes through a cyclone precleaner to remove some particulate, but emissions still amount to about 5 pounds per ton of product. The particulate emission rate increases as the particle size of the aggregate decreases.

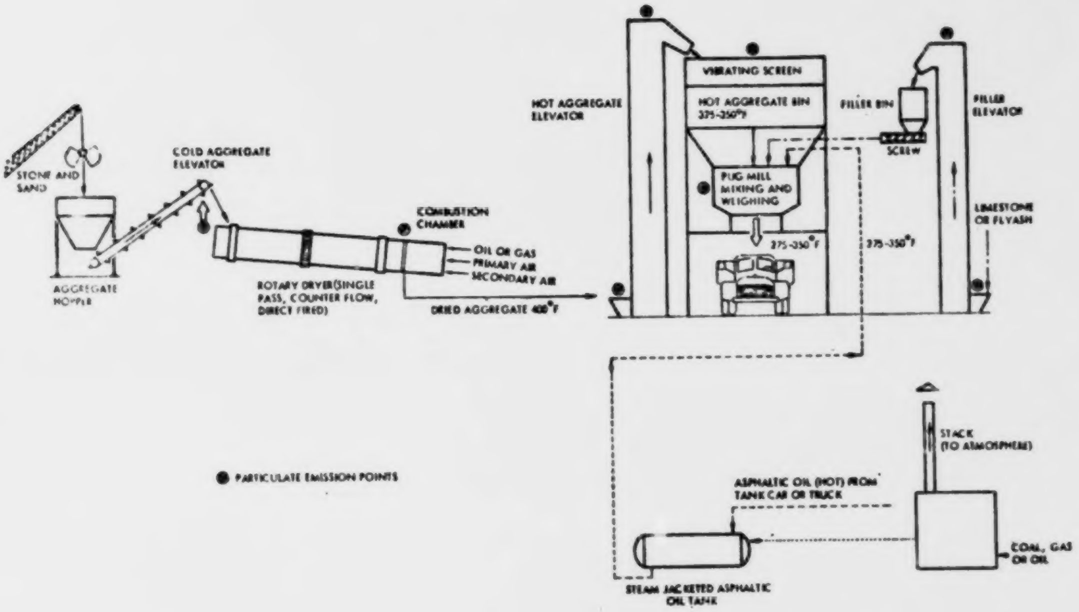

STONE AND SAND
AGGREGATE HOPPER
COLD AGGREGATE ELEVATOR
ROTARY DRYER(SINGLE PASS, COUNTER FLOW, DIRECT FIRED)
COMBUSTION CHAMBER
OIL OR GAS
PRIMARY AIR
SECONDARY AIR
DRIED AGGREGATE 400°F
HOT AGGREGATE ELEVATOR
VIBRATING SCREEN
HOT AGGREGATE BIN 375-350°F
PUG MILL MIXING AND WEIGHING
375-350°F
375-350°F
FILLER BIN
SCREW
FILLER ELEVATOR
LIMESTONE OR FLYASH
PARTICULATE EMISSION POINTS
STACK (TO ATMOSPHERE)
ASPHALTIC OIL (HOT) FROM TANK CAR OR TRUCK
COAL, GAS OR OIL
STEAM JACKETED ASPHALTIC OIL TANK

Figure 3.8.16 Asphalt batch plant.

Control Systems - Covering belt conveyors, elevators, screens, bins and other handling operations, and venting the displaced air through a fabric filter system will effectively control emissions from these sources.

A cyclone precleaner, followed by a fabric filter or high-energy wet scrubber can be used to reduce particulate emissions from the rotary dryer. Scrubber systems should provide at least 10 gallons of water per 1000 standard cubic feet of exhaust gas. Pressure drops through the scrubber should be in the range of 10 to 20 inches of water. Fabric filter systems commonly use glass fiber or Nomex fabric and operate at air-to-cloth ratios of 3.5 to 6.5 (CFM per ft^2).

Compliance Schedules - Figures 3.8.17 and 3.8.18 respectively illustrate expeditious schedules for installation of a wet scrubber and a fabric filter on a rotary kiln.

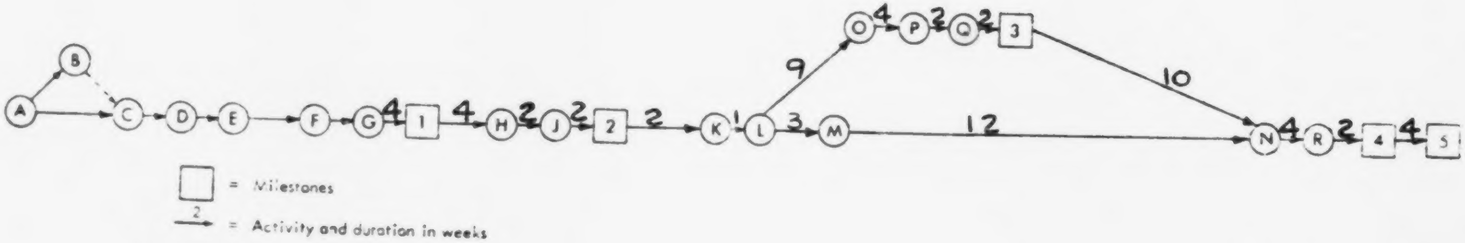
Because of the seasonal nature of the industry in the northern climates, field construction and control system tie-in are sometimes scheduled only during the winter and early spring to avoid financial hardships.

Sources of Additional Information

Source	Type of Information*
1) Air Pollution Engineering Manual PHS Publication No. 999-AP-40	P, E, C
2) Handbook of Emissions, Effluents, and Control Practices for Stationary Particulate Pollutant Sources NTIS No: PB 203-522	P, E, C

* P = Process description
E = Emission rates
C = Control devices

Figure 3.8.17 Schedule for installation of a wet scrubber on an asphalt batch plant for particulate pollutant control.



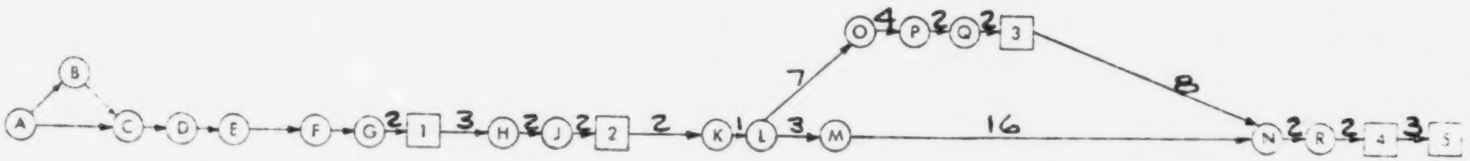
MILESTONES

		ELAPSED TIME (WEEKS)
1	Date of submittal of final control plan to appropriate agency.	4
2	Date of award of control device contract.	12
3	Date of initiation of on-site construction or installation of emission control equipment.	32
4	Date by which on-site construction or installation of emission control equipment is completed.	48
5	Date by which final compliance is achieved.	52

ACTIVITIES

Designation		Designation	
A-C	Preliminary investigation	K-L	Review and approval of assembly drawings
A-B	Source tests	L-M	Vendor prepares fabrication drawings
C-D	Evaluate control alternatives	M-N	Fabricate control device
D-E	Commit funds for total program	L-O	Prepare engineering drawings
E-F	Prepare preliminary control plan and compliance schedule for agency	O-P	Procure construction bids
F-G	Agency review and approval	P-Q	Evaluate construction bids
G-1	Finalize plans and specifications	Q-3	Award construction contract
1-H	Procure control device bids	3-N	On-site construction
H-J	Evaluate control device bids	N-R	Install control device
J-2	Award control device contract	R-4	Complete construction (system tie-in)
2-K	Vendor prepares assembly drawings	4-5	Startup, shakedown, preliminary source test

Figure 3.8.18 Schedule for installation of a fabric filter on an asphalt batch plant for particulate pollutant control.



□ = Milestones

$\xrightarrow{2}$ = Activity and duration in weeks

MILESTONES

		ELAPSED TIME (WEEKS)
1	Date of submittal of final control plan to appropriate agency.	2
2	Date of award of control device contract.	9
3	Date of initiation of on-site construction or installation of emission control equipment.	27
4	Date by which on-site construction or installation of emission control equipment is completed.	39
5	Date by which final compliance is achieved.	42

ACTIVITIES

Designation	
A-C	Preliminary investigation
A-B	Source tests
C-D	Evaluate control alternatives
D-E	Commit funds for total program
E-F	Prepare preliminary control plan and compliance schedule for agency
F-G	Agency review and approval
G-1	Finalize plans and specifications
1-H	Procure control device bids
H-J	Evaluate control device bids
J-2	Award control device contract
2-K	Vendor prepares assembly drawings

Designation	
K-L	Review and approval of assembly drawings
L-M	Vendor prepares fabrication drawings
M-N	Fabricate control device
L-O	Prepare engineering drawings
O-P	Procure construction bids
P-Q	Evaluate construction bids
Q-3	Award construction contract
3-N	On-site construction
N-R	Install control device
R-4	Complete construction (system tie-in)
4-5	Startup, shakedown, preliminary source test

3.8.7 Asphalt Roofing

Process Description - Asphalt roofings are made by impregnating a felt base with asphalt on high-speed, continuous machines, called asphalt saturators. Figure 3.8.19 schematically illustrates this process. The felt is fed continuously from rolls onto the dry looper, which provides live storage of felt so that changing rools will not interrupt production. From the dry looper, the felt travels to the spray section, where liquid asphalt heated to 400 to 450°F is sprayed on one side of the felt; this spraying drives the moisture out of the unsprayed side and prevents blisters when the felt is saturated. In the asphalt tank, the felt is impregnated with asphalt maintained at the desired temperature by continuous circulation through an asphalt heater. The impregnated felt then enters the wet looper, where it is cooled by traveling over sets of rollers arranged in long vertical loops. The impregnated felt is rolled at the discharge end of the wet looper for use as roofing felt; or rock granules, or other materials can be added and the felt cut for use as roofing shingles.

At some roofing plants, the asphalt saturant must first be processed. This preparation, called "blowing", consists of oxidizing the asphalt by bubbling air through it for 8 to 16 hours.

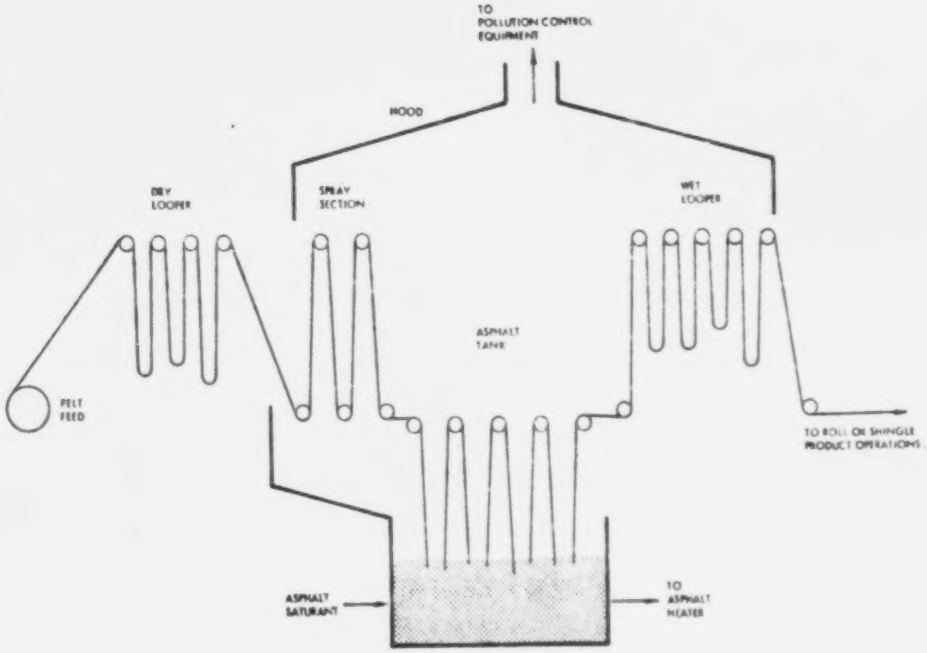

TO POLLUTION CONTROL EQUIPMENT
HOOD
DRY LOOPER
SPRAY SECTION
WET LOOPER
ASPHALT TANK
FELT FEED
TO ROLL OR SHINGLE PRODUCT OPERATIONS
ASPHALT SATURANT
TO ASPHALT HEATER

Figure 3.8.19 Manufacture of asphalt roofing materials.

Atmospheric Emissions - The relatively high temperature at which the asphalt is applied to the felt causes the lower-boiling-point components of the asphalt to vaporize. In addition, moisture in the felt vaporizes, resulting in steam distillation of the asphalt. The vaporized components subsequently condense as very fine particulate matter and create a highly visible plume. Emissions from the asphalt saturation operation without controls range from 1 to 3 pounds of particulate matter per ton of saturated felt produced.

The asphalt blowing operation is another significant source of air pollution. Uncontrolled emissions are approximately 2.5 pounds and 1.5 pounds of particulate and hydrocarbons, respectively, per ton of saturated felt produced.

Control Systems - A common method of control at asphalt saturating plants is the complete enclosure of the spray and saturator area, with ventilation through one or more control devices.

The two most effective control devices are direct-flame afterburners and high-energy air filters (HEAF). The latter is a disposable, once-through, moving filter pad of glass fiber through which the process exhausts pass. Generally, HEAF units are used on existing plants where heat recovery is not practical. Most new installations utilize afterburners with heat-recovery systems.

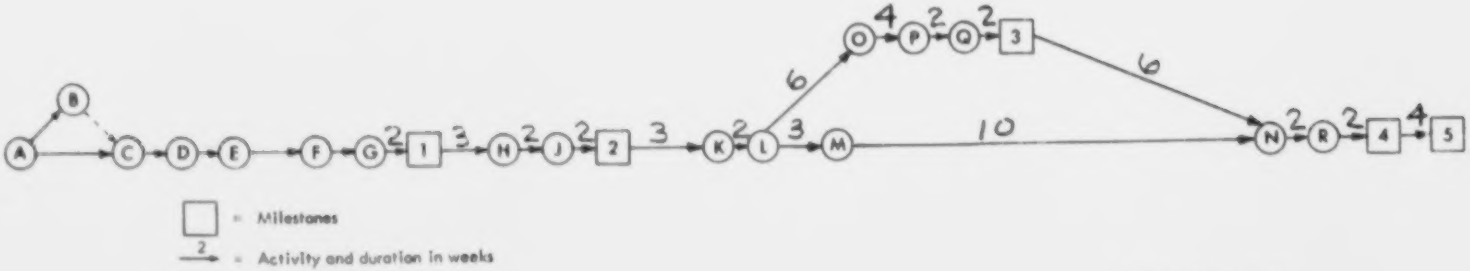
Compliance Schedules - Figures 3.8.20 and 3.8.21 illustrate expeditious schedules for installation of a direct-fired afterburner and a high-energy air filter, respectively.

Sources of Additional Information

Source	Type of Information*
1) Air Pollution Engineering Manual PHS Publication No. 999-AP-40	P, E, C

* P = Process description
E = Emission rates
C = Control devices

Figure 3.8.20 Schedule for installation of an afterburner on an asphalt roofing operation for particulate pollutant control.



MILESTONES

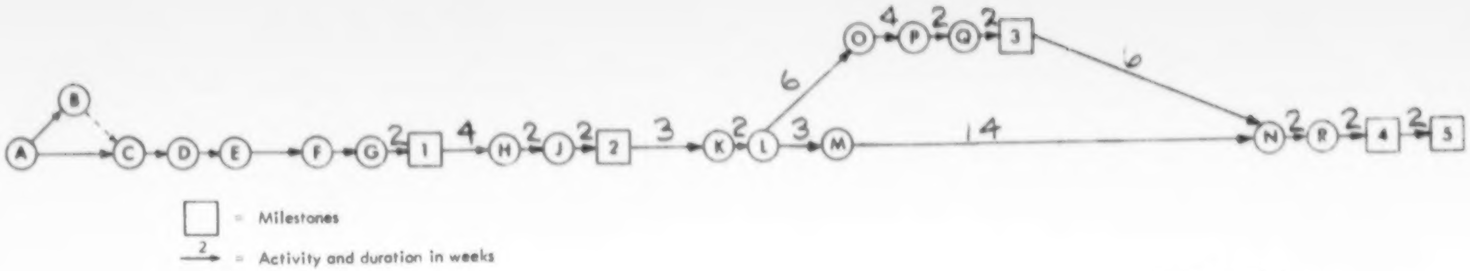
		ELAPSED TIME (WEEKS)
1	Date of submittal of final control plan to appropriate agency.	2
2	Date of award of control device contract.	9
3	Date of initiation of on-site construction or installation of emission control equipment.	28
4	Date by which on-site construction or installation of emission control equipment is completed.	38
5	Date by which final compliance is achieved.	42

ACTIVITIES

Designation	
A-C	Preliminary investigation
A-B	Source tests
C-D	Evaluate control alternatives
D-E	Commit funds for total program
E-F	Prepare preliminary control plan and compliance schedule for agency
F-G	Agency review and approval
G-1	Finalize plans and specifications
1-H	Procure control device bids
H-J	Evaluate control device bids
J-2	Award control device contract
2-K	Vendor prepares assembly drawings

Designation	
K-L	Review and approval of assembly drawings
L-M	Vendor prepares fabrication drawings
M-N	Fabricate control device
L-O	Prepare engineering drawings
O-P	Procure construction bids
P-Q	Evaluate construction bids
Q-3	Award construction contract
3-N	On-site construction
N-R	Install control device
R-4	Complete construction (system tie-in)
4-5	Startup, shakedown, preliminary source test

Figure 3.8.21 Schedule for installation of a HEAF unit on asphalt roofing operation for particulate pollutant control.



MILESTONES

		ELAPSED TIME (WEEKS)
1	Date of submittal of final control plan to appropriate agency.	2
2	Date of award of control device contract.	10
3	Date of initiation of on-site construction or installation of emission control equipment.	29
4	Date by which on-site construction or installation of emission control equipment is completed.	39
5	Date by which final compliance is achieved.	41

ACTIVITIES

Designation		Designation	
A-C	Preliminary investigation	K-L	Review and approval of assembly drawings
A-B	Source tests	L-M	Vendor prepares fabrication drawings
C-D	Evaluate control alternatives	M-N	Fabricate control device
D-E	Commit funds for total program	L-O	Prepare engineering drawings
E-F	Prepare preliminary control plan and compliance schedule for agency	O-P	Procure construction bids
F-G	Agency review and approval	P-Q	Evaluate construction bids
G-1	Finalize plans and specifications	Q-3	Award construction contract
1-H	Procure control device bids	3-N	On-site construction
H-J	Evaluate control device bids	N-R	Install control device
J-2	Award control device contract	R-4	Complete construction (system tie-in)
2-K	Vendor prepares assembly drawings	4-5	Startup, shakedown, preliminary source test

3.8.8 Concrete Batching

Process Description - Three types of concrete batching plants are in use: wet-batch plants, central mix plants, and to a much lesser extent, dry-mix plants. In wet-batch plants, sand, aggregates, and cement are mixed in proper proportions and dropped into a transit-mix truck. Water is added simultaneously, as shown in Figure 3.8.22.

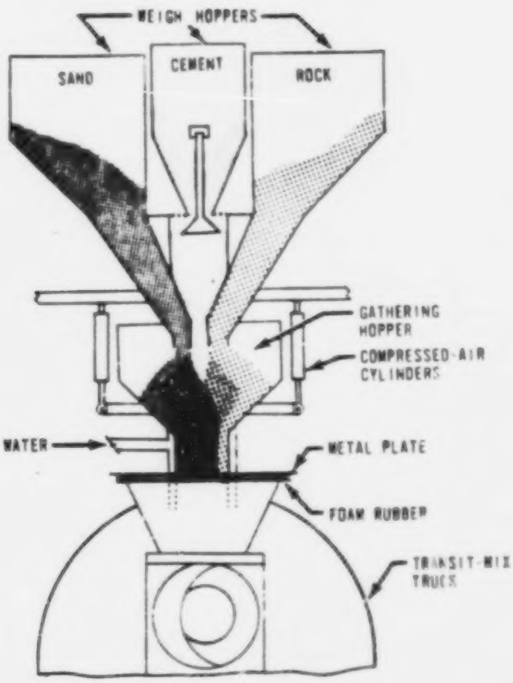

WEIGH HOPPERS
SAND
CEMENT
ROCK
GATHERING HOPPER
COMPRESSED-AIR CYLINDERS
WATER
METAL PLATE
FOAM RUBBER
TRANSIT-MIX TRUCK

Figure 3.8.22 Wet-concrete batch loading operation

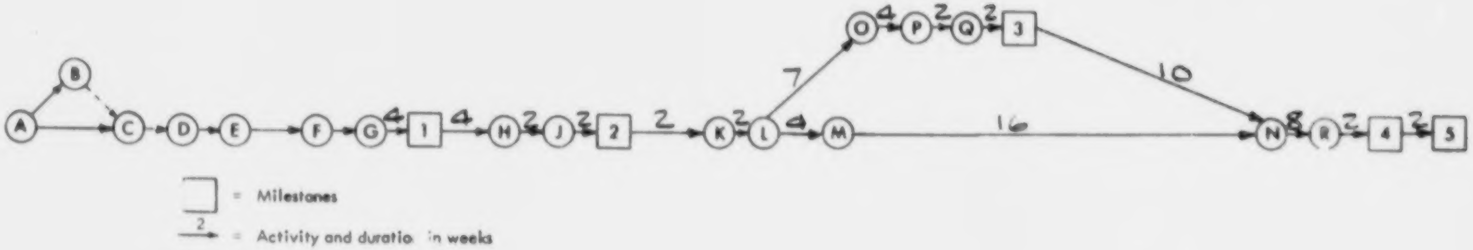
In central mix plants, the raw materials are mixed at a central plant and wet concrete is delivered to the job site in open trucks. In dry-mix plants, sand, aggregate and cement are mixed dry; water is added and the concrete is mixed at the job site.

Atmospheric Emissions - Particulates can be emitted in significant quantities from receiving and conveying of cement, sand, and aggregates, and from load-out of the concrete. Factors affecting the emission rate include the amount and particle size of the materials handled, and the type of handling systems used. Particulate emissions from an uncontrolled wet-batch plant are approximately 0.2 pound per cubic yard of concrete. Dry-mix plants have a much higher emission potential.

Control Methods - Enclosure of dumping areas and of conveyors and elevators, together with the use of bin vent filters will substantially reduce particulate emissions. Wet scrubbers have encountered operational difficulties such as plugged spray nozzles, corrosion, and waste-water disposal problems.

Compliance Schedules - Figure 3.8.23 illustrates an expeditious schedule for installation of a fabric filter on a concrete batch plant.

Figure 3.8.23 Schedule for installation of a fabric filter on a concrete batch plant for particulate pollutant control.



MILESTONES

		ELAPSED TIME (WEEKS)
1	Date of submittal of final control plan to appropriate agency.	9
2	Date of award of control device contract.	12
3	Date of initiation of on-site construction or installation of emission control equipment.	31
4	Date by which on-site construction or installation of emission control equipment is completed.	51
5	Date by which final compliance is achieved.	53

ACTIVITIES

Designation	
A-C	Preliminary investigation
A-B	Source tests
C-D	Evaluate control alternatives
D-E	Commit funds for total program
E-F	Prepare preliminary control plan and compliance schedule for agency
F-G	Agency review and approval
G-1	Finalize plans and specifications
1-H	Procure control device bids
H-J	Evaluate control device bids
J-2	Award control device contract
2-K	Vendor prepares assembly drawings

Designation	
K-L	Review and approval of assembly drawings
L-M	Vendor prepares fabrication drawings
M-N	Fabricate control device
L-O	Prepare engineering drawings
O-P	Procure construction bids
P-Q	Evaluate construction bids
Q-3	Award construction contract
3-N	On-site construction
N-R	Install control device
R-4	Complete construction (system tie-in)
4-5	Startup, shakedown, preliminary source test

Sources of Additional Information

Source	Type of Information*
1) Air Pollution Engineering Manual PHS Publication No. 999-AP-40	P,E,C
2) Exhaust Gases from Combustion and Industrial Processes NTIS Publication No. PB 204-861	P,C

* P = Process description
E = Emission rates
C = Control devices

3.9 Petroleum Industry

3.9.1 Petroleum Refining

Process Description - Petroleum refineries normally range in size from 20,000 barrels per day or less to 200,000 barrels per day or more for a complete modern refinery.

Crude oil is initially separated by distillation into boiling range fractions (e.g., gas, naphtha, kerosene, middle distillates, and heavy bottoms). Since these fractions seldom conform to either product demand or quality requirements, the less desirable fractions are converted to more marketable products. This conversion normally consists of splitting, uniting, or rearranging the original molecular structure. The subsequent separation and conversion products are then treated for removal of undesirable components, and blended with each other and a variety of additives to meet product specifications.

The conversion processes consist of hydro-, catalytic-, and thermal-cracking which function principally to produce smaller, lower-boiling-point hydrocarbons. Catalytic reforming produces higher quality gasoline mainly by isomerizing and aromatizing naphtha. Polymerization combines two or more gaseous olefins, while alkylation combines an olefin with an isoparaffin to form gasoline range hydrocarbons. An isomerization unit is used to increase molecular branch chain formation and increase gasoline quality. The most common treating processes, such as caustic treating, hydrotreating, and desulfurization are used to reduce the product's sulfur content.

Figures 3.9.1 and 3.9.2 illustrate processing plans for intermediate and complete refineries, respectively.

Atmospheric Emissions - Refinery operations entail a number of emission sources, including storage tanks, waste-water sewer systems, pumping systems, blowdown systems, boilers and process heaters, and catalytic regeneration units. Emissions from many of these sources can be effectively controlled by proper design and maintenance.

Storage tanks are significant potential sources of hydrocarbon emissions, particularly those storing crude oil and light distillates. Vapor is lost mainly from direct evaporation and displacement during filling. Hydrocarbon losses can be minimized by the use of pressure tanks, vapor-recovery systems, or floating-roof tanks, as described in Section 3.3.2.

The waste-water sewer system can also cause significant hydrocarbon emissions unless it is properly designed and

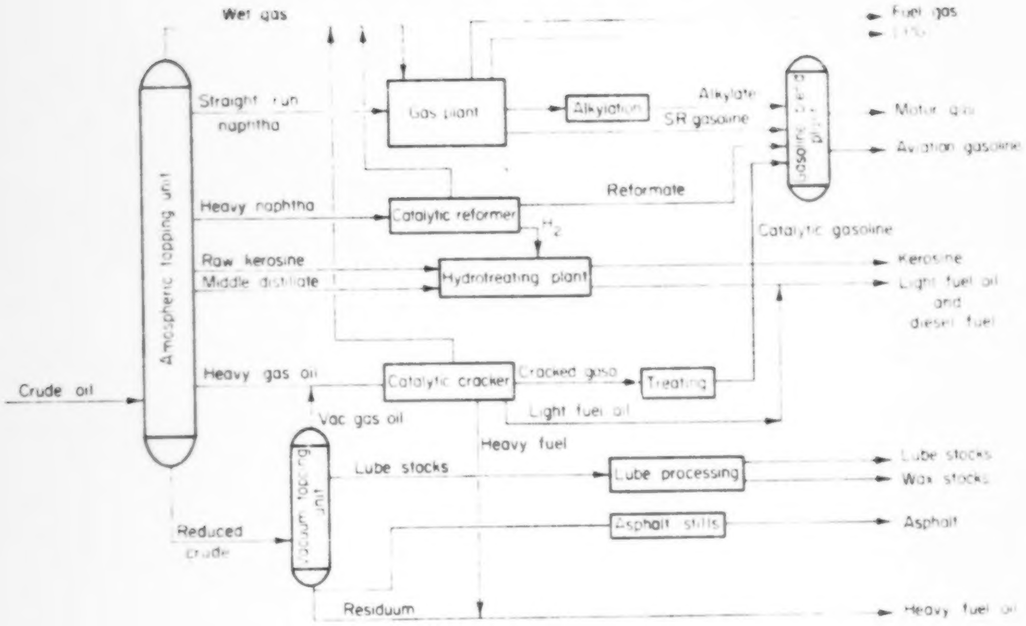

Wet gas
Fuel gas
LPG
Straight run naphtha
Gas plant
Alkylation
Alkylate
SR gasoline
Gasoline blend plant
Motor gas
Aviation gasoline
Reformate
Heavy naphtha
Catalytic reformer
H_2
Catalytic gasoline
Raw kerosine
Middle distillate
Hydrotreating plant
Kerosine
Light fuel oil and diesel fuel
Amospheric topping unit
Heavy gas oil
Catalytic cracker
Cracked gaso
Treating
Crude oil
Light fuel oil
Vac gas oil
Heavy fuel
Vacuum topping unit
Lube stocks
Lube processing
Lube stocks
Wax stocks
Reduced crude
Asphalt stills
Asphalt
Residuum
Heavy fuel oil

Figure 3.9.1 Intermediate refinery
(Source: Stern. Sources of Air Pollution and Their Control.)

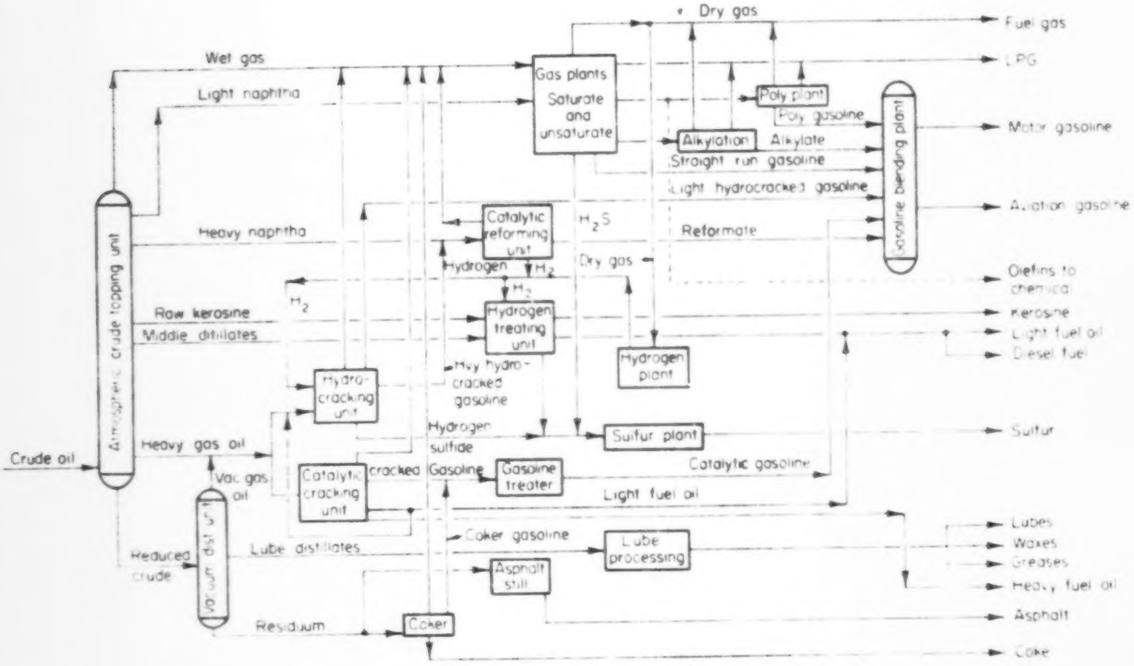

Dry gas
Fuel gas
Wet gas
LPG
Gas plants
Saturate and unsaturate
Light naphtha
Poly plant
Poly gasoline
Alkylation
Alkylate
Gasoline blending plant
Motor gasoline
Straight run gasoline
Light hydrocracked gasoline
Aviation gasoline
Catalytic reforming unit
H_2S
Heavy naphtha
Reformate
Hydrogen
H_2
Dry gas
Olefins to chemical
H_2
Raw kerosine
Middle ditillates
Hydrogen treating unit
Kerosine
Light fuel oil
Diesel fuel
Atmospheric crude topping unit
Hydrogen plant
Hydro-cracking unit
Hvy hydro-cracked gasoline
Hydrogen sulfide
Sulfur plant
Sulfur
Heavy gas oil
Crude oil
Vac gas oil
Catalytic cracking unit
cracked Gasoline
Gasoline treater
Catalytic gasoline
Light fuel oil
Vacuum dist unit
Lubes
Coker gasoline
Waxes
Reduced crude
Lube distillates
Lube processing
Greases
Asphalt still
Heavy fuel oil
Asphalt
Residuum
Coker
Coke

Figure 3.9.2 Complete refinery.
(Source: Stern. Sources of Air Pollution and Their Control.)

maintained. The front end of the waste-water gravity separator can be covered. Catch basin liquid seals, manhole covers, and other good housekeeping practices;will reduce drainage system vapor losses.

The complex network of piping and valves is a large potential source of hydrocarbon emissions but can be controlled by good maintenance practices. Hydrocarbon emissions from pumps and compressors can be reduced by proper maintenance and the use of mechanical seals in light hydrocarbon service.

Blowdown systems, which are used during startups and shutdowns of process units to vent hydrocarbon vapors and during routine operation to capture various hydrocarbon leaks and relief valve venting, are designed to recover condensable hydrocarbons and flare the non-condensibles. Emissions can be minimized by utilizing a properly designed steam or air injection smokeless flare.

Boiler and process heaters using heavy fuel oil are a major source of particulates, nitrogen oxides, and sulfur oxides. Significant quantities of hydrocarbons and aldehydes can also be emitted.

The catalyst regeneration system of the catalytic-cracking unit is a major source of carbon monoxide, sulfur and nitrogen oxides, hydrocarbons, and particulate emissions. In the Fluid

Catalytic Cracking Unit, the most common type used in larger refineries, the catalyst is regenerated in a continuous moving bed to maintain unit heat balance and burn off coke formed on the catalyst surface.

Regeneration of fixed bed reforming, hydrotreating and hydrocracking catalyst is normally done in batch during a shutdown. The regeneration consists of burning coke and other deposits off the catalyst with a circulating inert gas stream containing a controlled oxygen content. Regeneration of reforming catalyst emits CO_2 and some halides as acid mist. The regeneration of hydrotreating and hydrocracking catalyst emits CO_2, SO_2, ammonia, and other minor impurities.

Control Systems - As mentioned earlier, many emissions may be effectively reduced by proper maintenance or by venting to a vapor recovery or flare system.

Sulfur-laden hydrocarbon vapor streams are normally treated by amine treaters, which yield a recoverable hydrocarbon stream and a stream high in H_2S. Vapor streams rich in H_2S can be controlled by a sulfur plant (Claus Unit) which recovers elemental sulfur; Claus plant sulfur removal efficiencies are approximately 93 to 99 percent. Several processes are available to reduce the sulfur content of the tail gas from a Claus Unit, some of which process the tail gas before incineration and some after incineration. The product stream is either elemental sulfur or SO_2. Among the processes available that appear acceptable are the Beavon Sulfur Removal Process, the Clean Air Sulfur Process, the Shell Flue Gas Desulfurization Process, and the Wellman-Power Gas SO_2 Recovery Process.

Carbon monoxide and hydrocarbon emissions from a Fluid Catalytic Cracking Unit can be controlled by waste heat boilers, and particulate emissions by electrostatic precipitators. Waste heat boilers are normally used on all large units for heat recovery. Multi-stage cyclones, which are an integral part of the cracking unit, will also reduce the particulate load to the precipitator.

Emissions from fixed bed catalyst regeneration can be controlled by passing regeneration gases through a caustic scrubber and venting the wet gas to a fire box.

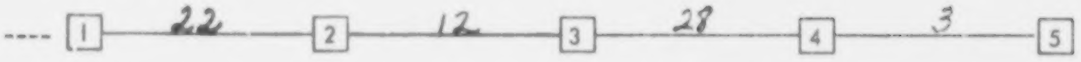
Compliance Schedules - Figures 3.9.3, 3.9.4, 3.9.5, and 3.9.6 illustrate expeditious schedules for installation of an amine treater-sulfur plant,a tail gas desulfurization unit, a package amine treater-sulfur plant and tail gas desulfurization plant, and an electrostatic precipitator, respectively. For tail gas desulfurization, the schedule represents an average time requirement for the several processes available.

Sources of Additional Information

Source	Type of Information*
1) Air Pollution Engineering Manual PHS Publication No. 999-AP-40	P, E, C
2) Air Pollution, A.C. Stern, Vol. III Chapter 34 - Petroleum Refinery Emissions, Academic Press, 1968	P, C
3) Petroleum Refinery Engineering W.L. Nelson, McGraw-Hill 1958	P, C
4) Atmospheric Emissions from Petroleum Refineries - A Guide for Measurement and Control NTIS No. PB 198-096	E

* P = Process description
E = Emission rates
C = Control devices

Figure 3.9.3 Schedule for installation of an amine-treater-sulfur plant for hydrogen sulfide emission control.

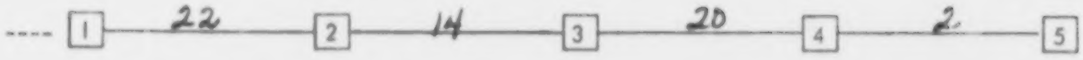


MILESTONES		ELAPSED TIME (WEEKS)
1	Date of submittal of final control plan to appropriate agency.	4
2	Date of award of control device contract.	26
3	Date of initiation of on-site construction or installation of emission control equipment.	38
4	Date by which on-site construction of emission control equipment is completed.	66
5	Date by which final compliance is achieved.	69

ACTIVITIES

DESIGNATIONS	
1 - 2	Preparation of detailed engineering and fabrication drawings, equipment specifications, construction bid documents and award of construction contract.
2 - 3	Equipment fabrication and delivery of structural components to site.
3 - 4	Delivery of remaining equipment and completion of construction including process tie in.
4 - 5	Equipment start up and source testing.

Figure 3.9.4 Schedule for installation of a tail gas desulfurization unit for sulfur oxide emissions control.

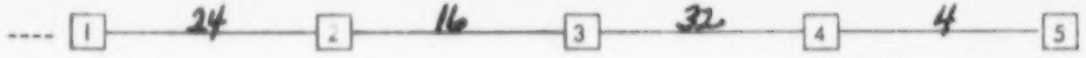


MILESTONES		ELAPSED TIME (WEEKS)
1	Date of submittal of final control plan to appropriate agency.	4
2	Date of award of control device contract.	26
3	Date of initiation of on-site construction or installation of emission control equipment.	40
4	Date by which on-site construction of emission control equipment is completed.	60
5	Date by which final compliance is achieved.	62

ACTIVITIES

DESIGNATIONS	
1 - 2	Preparation of detailed engineering and fabrication drawings, equipment specifications, construction bid documents and award of construction contract.
2 - 3	Equipment fabrication and delivery of structural components to site.
3 - 4	Delivery of remaining equipment and completion of construction including process tie in.
4 - 5	Equipment start up and source testing.

Figure 3.9.5 Schedule for installation of an amine treater, a sulfur plant and a tail-gas desulfurization unit.

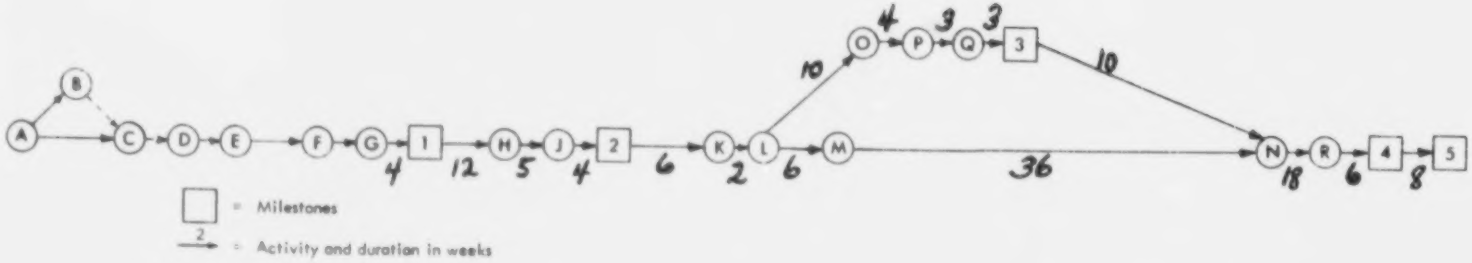


MILESTONES		ELAPSED TIME (WEEKS)
1	Date of submittal of final control plan to appropriate agency.	4
2	Date of award of control device contract.	28
3	Date of initiation of on-site construction or installation of emission control equipment.	44
4	Date by which on-site construction of emission control equipment is completed.	76
5	Date by which final compliance is achieved.	80

ACTIVITIES

DESIGNATIONS	
1 - 2	Preparation of detailed engineering and fabrication drawings, equipment specifications, construction bid documents and award of construction contract.
2 - 3	Equipment fabrication and delivery of structural components to site.
3 - 4	Delivery of remaining equipment and completion of construction including process tie in.
4 - 5	Equipment start up and source testing.

Figure 3.9.6 Schedule for installation of an electrostatic precipitator for particulate pollutant control.



MILESTONES

		ELAPSED TIME (WEEKS)
1	Date of submittal of final control plan to appropriate agency.	4
2	Date of award of control device contract.	25
3	Date of initiation of on-site construction or installation of emission control equipment.	63
4	Date by which on-site construction or installation of emission control equipment is completed.	99
5	Date by which final compliance is achieved.	107

ACTIVITIES

Designation	
A-C	Preliminary investigation
A-B	Source tests
C-D	Evaluate control alternatives
D-E	Commit funds for total program
E-F	Prepare preliminary control plan and compliance schedule for agency
F-G	Agency review and approval
G-1	Finalize plans and specifications
1-H	Procure control device bids
H-J	Evaluate control device bids
J-2	Award control device contract
2-K	Vendor prepares assembly drawings

Designation	
K-L	Review and approval of assembly drawings
L-M	Vendor prepares fabrication drawings
M-N	Fabricate control device
L-O	Prepare engineering drawings
O-P	Procure construction bids
P-Q	Evaluate construction bids
Q-3	Award construction contract
3-N	On-site construction
N-R	Install control device
R-4	Complete construction (system tie-in)
4-5	Startup, shakedown, preliminary source test

3.10 Pulp and Paper

3.10.1 Kraft Process

Process Description - The Kraft Process, shown schematically in Figure 3.10.1, uses an aqueous solution of sodium hydroxide or sodium hydroxide and sodium sulfide to dissolve the lignin binding the wood fibers. This solution, the "white liquor", is mixed with wood chips in a large pressure vessel, the digester, and cooked for several hours with steam.

When the cooking is completed, the contents of the digester are forced into a blow tank. The pulp is then separated from the spent black liquor, washed in several stages, and bleached before it is sent to the paper mill for further processing.

The spent "black" liquor together with the water from the pulp washer is initially concentrated in a multiple effect evaporator. It is usually further concentrated by direct contact evaporation with the flue gas from the recovery boiler. The combustible, concentrated black liquor from the direct contact evaporator is injected into the recovery boiler and burned. Heat is recovered in the form of steam and the inorganic chemicals in the spent liquor fall to the floor of the furnace in a molten state.

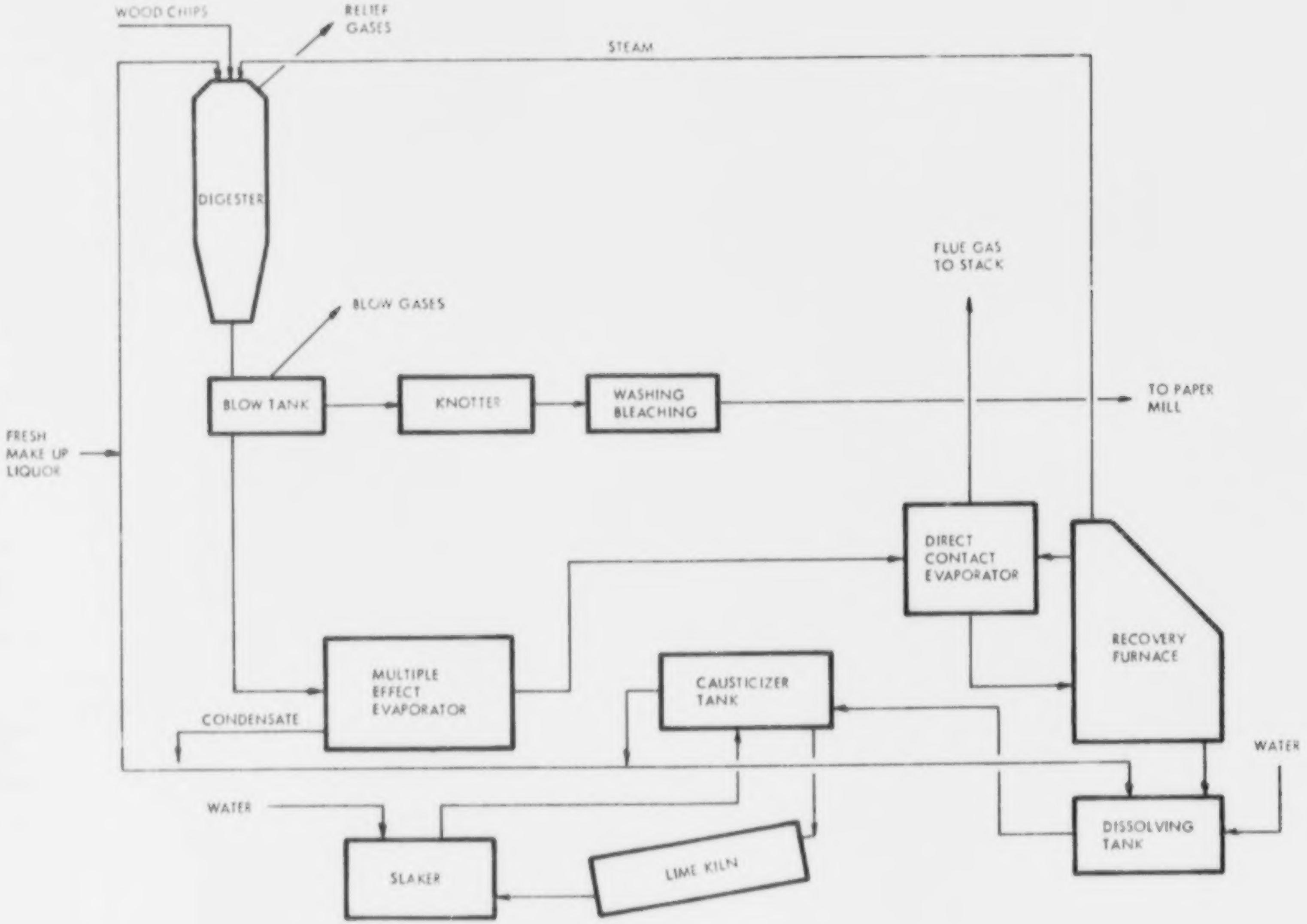

WOOD CHIPS
RELIEF GASES
STEAM
DIGESTER
BLOW GASES
FLUE GAS TO STACK
BLOW TANK
KNOTTER
WASHING BLEACHING
TO PAPER MILL
FRESH MAKE UP LIQUOR
DIRECT CONTACT EVAPORATOR
RECOVERY FURNACE
MULTIPLE EFFECT EVAPORATOR
CAUSTICIZER TANK
CONDENSATE
WATER
WATER
DISSOLVING TANK
SLAKER
LIME KILN

Figure 3.10.1 Kraft Process

The resulting melt, which consists essentially of a mixture of sodium sulfide and sodium carbonate, is withdrawn from the furnace and dissolved in water and weak liquor from the causticizing plant. The "green" liquor thus produced is further treated with calcium hydroxide to convert the sodium carbonate to sodium hydroxide. The calcium carbonate precipitates from the solution and is collected and sent to the lime kiln. There it is calcined to calcium oxide, which is slaked and converted back to calcium hydroxide. This treatment of the "green" liquor produces the "white" cooking liquor used in the digester.

Atmospheric Emissions - The major sources of particulate emission from the Kraft pulp mill, in decreasing order of importance, are 1) the recovery furnace, 2) the lime kiln and 3) the smelt dissolving tank.

It is estimated that 150 pounds of particulates would be emitted from an uncontrolled recovery furnace for every ton of air-dried pulp produced. The corresponding figures for the lime kiln and the smelt dissolving tank are 45 pounds per ADT and 2 pounds per ADT, respectively.

Odors can be a serious emission problem especially if direct contact evaporation is used or the recovery boiler is improperly operated. Sulfur oxides can also be emitted from the recovery boiler.

Control Systems - Electrostatic precipitators are commonly used to control emissions from recovery furnaces, and wet scrubbers to control emissions from lime kilns and smelt dissolving tanks.

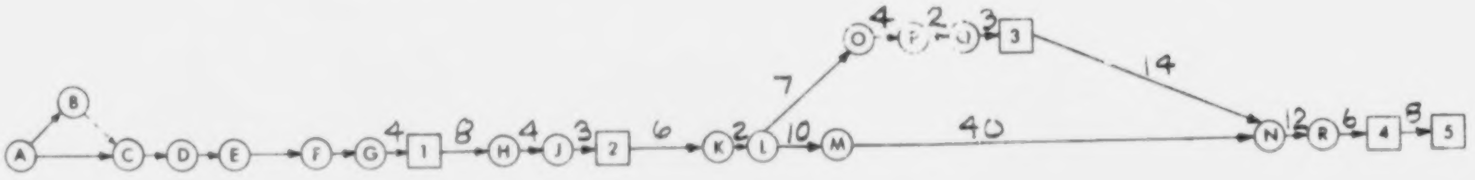
Compliance Schedules - Figures 3.10.2 and 3.10.3, respectively, illustrate expeditious schedules for installation of an electrostatic precipitator and a wet scrubber for particulate emission control.

Sources of Additional Information

Source	Type of Information
1) Handbook of Emissions, Effluents, and Control Practices for Stationary Particulate Pollution Sources NTIS No. PB 203-522	P, E, C
2) A Manual of Electrostatic Precipitator Technology, Part II - Application Areas, NTIS No. PB 196-381	C
3) Encyclopedia of Chemical Technology Kirk-Othmer, Vol. 16, 2nd Edition	P
4) Control of Atmospheric Emissions in the Wood Pulping Industry NTIS No. PB 190-351, 342, 353	P, E, C

* P = Process description
E = Emission rates
C = Control devices

Figure 3.10.2 Schedule for installation of an electrostatic precipitator on recovery boiler in pulp mill for particulate pollutant control.



□ = Milestones

$\xrightarrow{2}$ = Activity and duration in weeks

MILESTONES

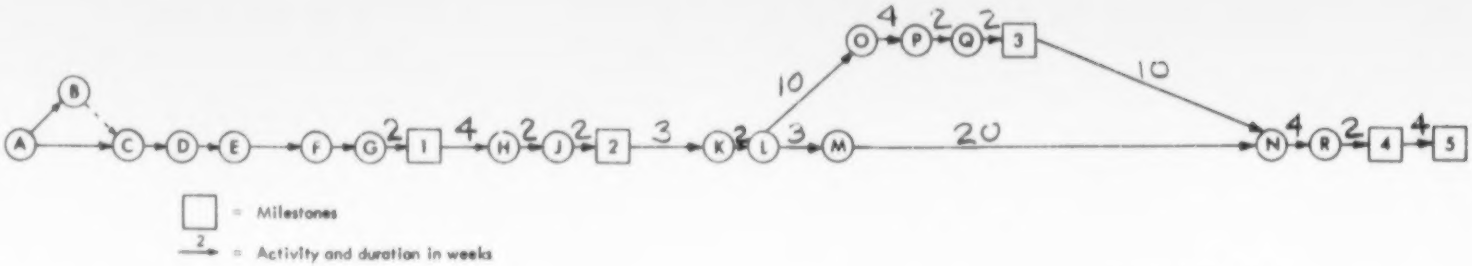
		ELAPSED TIME (WEEKS)
1	Date of submittal of final control plan to appropriate agency.	4
2	Date of award of control device contract.	19
3	Date of initiation of on-site construction or installation of emission control equipment.	43
4	Date by which on-site construction or installation of emission control equipment is completed.	95
5	Date by which final compliance is achieved.	103

ACTIVITIES

Designation	
A-C	Preliminary investigation
A-B	Source tests
C-D	Evaluate control alternatives
D-E	Commit funds for total program
E-F	Prepare preliminary control plan and compliance schedule for agency
F-G	Agency review and approval
G-1	Finalize plans and specifications
1-H	Procure control device bids
H-J	Evaluate control device bids
J-2	Award control device contract
2-K	Vendor prepares assembly drawings

Designation	
K-L	Review and approval of assembly drawings
L-M	Vendor prepares fabrication drawings
M-N	Fabricate control device
L-O	Prepare engineering drawings
O-P	Procure construction bids
P-Q	Evaluate construction bids
Q-3	Award construction contract
3-N	On-site construction
N-R	Install control device
R-4	Complete construction (system tie-in)
4-5	Startup, shakedown, preliminary source test

Figure 3.10.3 Schedule for installation of a wet scrubber on lime kiln and smelt dissolving tank in a Kraft mill for particulate pollutant control.



MILESTONES

		ELAPSED TIME (WEEKS)
1	Date of submittal of final control plan to appropriate agency.	2
2	Date of award of control device contract.	10
3	Date of initiation of on-site construction or installation of emission control equipment.	33
4	Date by which on-site construction or installation of emission control equipment is completed.	49
5	Date by which final compliance is achieved.	53

ACTIVITIES

Designation	
A-C	Preliminary investigation
A-B	Source tests
C-D	Evaluate control alternatives
D-E	Commit funds for total program
E-F	Prepare preliminary control plan and compliance schedule for agency
F-G	Agency review and approval
G-1	Finalize plans and specifications
1-H	Procure control device bids
H-J	Evaluate control device bids
J-2	Award control device contract
2-K	Vendor prepares assembly drawings

Designation	
K-L	Review and approval of assembly drawings
L-M	Vendor prepares fabrication drawings
M-N	Fabricate control device
L-O	Prepare engineering drawings
O-P	Procure construction bids
P-Q	Evaluate construction bids
Q-3	Award construction contract
3-N	On-site construction
N-R	Install control device
R-4	Complete construction (system tie-in)
4-5	Startup, shakedown, preliminary source test

3.10.2 Sulfite Pulping

Process Description - Pulp mills operating with acid cooking liquor and having no recovery system for spent liquor pose a problem of water rather than air pollution. Restrictions on the discharge of the spent liquor to surface waters will make mandatory the installation of spent recovery systems at those plants that have not already installed such a system. However, in treating the water pollution problem an air pollution problem is created. For this reason a control system designed for water treatment also must include air pollution control.

The several commercial systems for treatment of spent sulfite liquor follow basically the same steps: 1) concentration of the dilute spent liquor to a point where it can sustain combustion; 2) burning of the concentrate and recovery of the base chemical and heat; and 3) flue gas quenching and control of sulfur dioxide by scrubbing the gas with a solution containing the recovered base chemical. A simplified flow diagram of the process is shown in Figure 3.10.4.

Dilute spent sulfite liquor from the pulp washer is sent to a multiple effect evaporator where water is driven off and the liquor is concentrated to about 50 percent solids. Some volatile hydrocarbons, such as acetic acid, are also driven off and leave the evaporators with the condensate to water treatment system for BOD/COD reduction. The concentrated liquor is combusted in the primary recovery furnace, and steam is generated from the heat of combustion. The recoverable chemical base, such as magnesium,

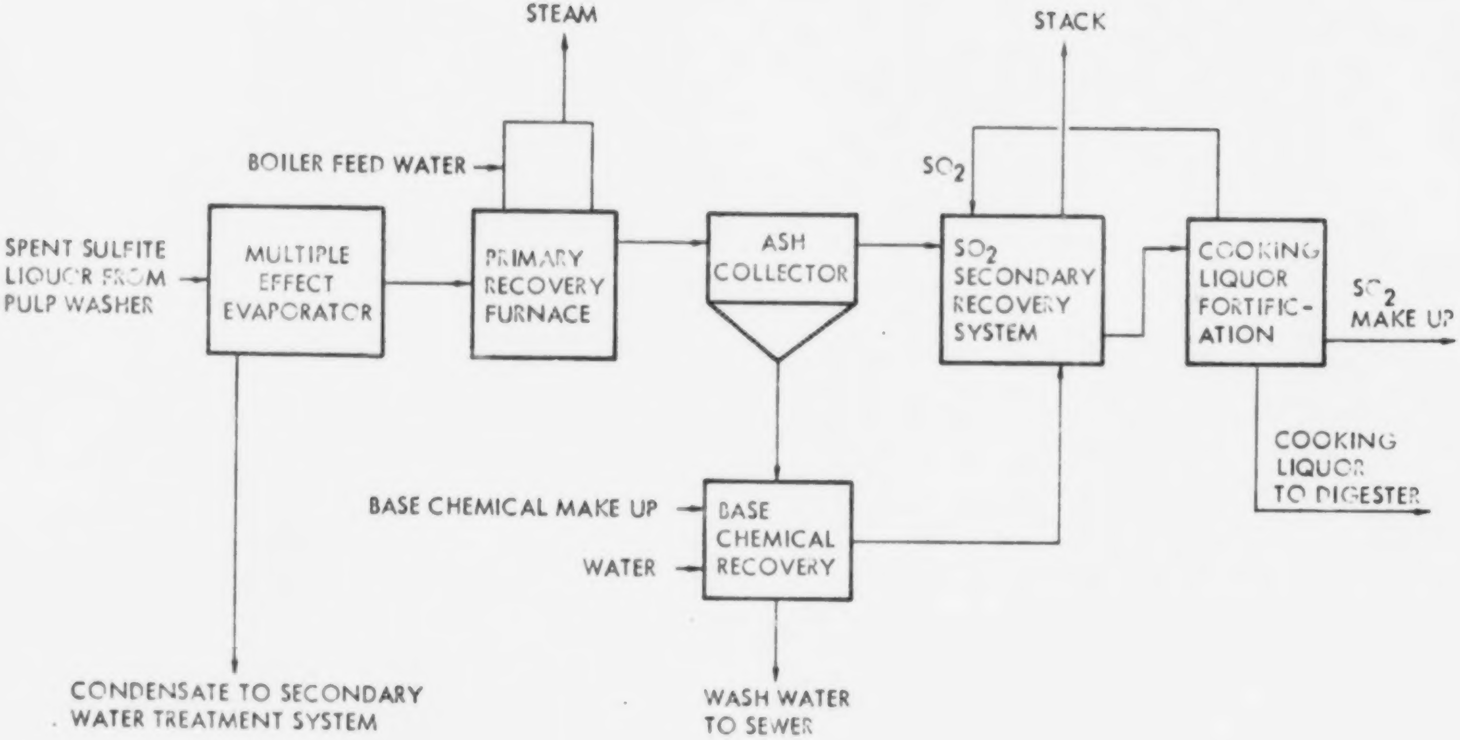

STEAM
STACK
BOILER FEED WATER
SO_2
SPENT SULFITE LIQUOR FROM PULP WASHER
MULTIPLE EFFECT EVAPORATOR
PRIMARY RECOVERY FURNACE
ASH COLLECTOR
SO_2 SECONDARY RECOVERY SYSTEM
COOKING LIQUOR FORTIFICATION
SO_2 MAKE UP
COOKING LIQUOR TO DIGESTER
BASE CHEMICAL MAKE UP
WATER
BASE CHEMICAL RECOVERY
CONDENSATE TO SECONDARY WATER TREATMENT SYSTEM
WASH WATER TO SEWER

Figure 3.10.4 Spent sulfite liquor recovery system.

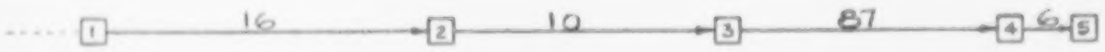
is collected through a multi-cyclone dry collector or an electrostatic precipitator. If the base is not recoverable, as with ammonia, then no ash collector is needed, since the ammonia is also combusted in the furnace and emitted as nitrogen and NO_x compounds. The recoverable base, in the form of an oxide, is washed to remove soluble impurities such as the sulfates, then slaked to form the hydroxide, which is then used as the chemical base in the SO_2 secondary recovery system to scrub the SO_2 from the gas and form a weak sulfite liquor. This weak liquor is fortified by injection of SO_2 under low pressure to form rich cooking liquor, which is sent back to the digester.

The gases from the secondary system leave the stack as essentially inerts and moisture, with traces of SO_2 and NO_x.

A poorly designed or improperly operated spent liquor recovery system can be a source of air pollution.

Compliance Schedules - A compliance schedule for construction and startup of a properly designed spent liquor recovery system is shown in Figure 3.10.5. The duration of this compliance schedule should be sufficient for the simultaneous installation of any associated water treatment system that may be required for BOD reduction.

Figure 3.10.5 Schedule for installation of a spent sulfite liquor recovery system in a pulp mill.



MILESTONES		ELAPSED TIME (WEEKS)
1	Date of submittal of final control plan to appropriate agency.	0
2	Date of award of control device contract.	16
3	Date of initiation of on-site construction or installation of emission control equipment.	26
4	Date by which on-site construction of emission control equipment is completed.	113
5	Date by which final compliance is achieved.	119

ACTIVITIES

DESIGNATIONS	
1 - 2	Preparation of detailed engineering and fabrication drawings, equipment specifications, construction bid documents and award of construction contract.
2 - 3	Equipment fabrication and delivery of structural components to site.
3 - 4	Delivery of remaining equipment and completion of construction including process tie in.
4 - 5	Equipment start up and source testing.

4.0 SUPPORTING DATA

4.1 Vendor Data

4.1.1 Quoted Delivery Schedules

Nine major manufacturers of air pollution control equipment were contacted to provide information on the time required for design and fabrication of control devices. Except for installation of electrostatic precipitators, manufacturers agreed substantially with regard to quoted schedules. Electrostatic precipitators require the longest delivery times, and variation among suppliers' schedules is significant. A relatively small number of recognized firms sell precipitators, and the market is dominated by a few major manufacturers; this situation stems from the complexity of electrostatic precipitator design.

Data obtained from vendors are summarized by control device type in the following sections.

Electrostatic Precipitators - Schedules for activities in the fabrication and installation of electrostatic precipitators, obtained from seven precipitator manufacturers, are presented in Table 4.1. Data provided by vendors (A) and (G) were disregarded as being out of line with those provided by the other vendors; since these vendors command a small share of the precipitator market, schedules based on their figures would not provide proper guidelines for evaluating compliance schedules submitted for most emission sources.

Table 4.1 VENDOR DELIVERY SCHEDULES FOR ELECTROSTATIC PRECIPITATORS

Vendor	Equip. Size, CFM	Assembly Drawings	Fabrication Drawings	Initial Delivery To Construction Site	Completion of Construction Since Initial Delivery	Debugging	Testing
A	<200,000	4-6 Wks	10-14 Wks	10 Wks	8 Wks	2 Wks	4 Wks
A	>200,000	4-6	10-14	14 Wks.	12	2	4
B	<100,000	3	12	40 Wks		3	9-18
B	>100,000	3	12	52 Wks		4	12-24
C	Small		12	27-36	13	6	2
C	350,000		12	27-36	13	6	2
D	<100,000		12	12-16	12-20	2	
D	>100,000		12	12-16	12-20	2	2
E	Small		6-8	42	3	2	
E	Large		6-8	42	3	2	
F	Small						
F	~100,000		4-5	36	10-12		
G	100,000-500,000		2-4	14-16	12	2 Wks.	2

Table 4.2 VENDOR DELIVERY SCHEDULES FOR FABRIC FILTERS

Vendor	Equip. Size, CFM	Assembly Drawings	Fabrication Drawings	Initial Delivery To Construction Site	Completion of Construction Since Initial Delivery	Debugging	Testing
A	<150,000		2 Wks	10-14 Wks	1-2 Wks	1-2 Wks	1 Wk
A	>150,000		2	~18	~3	2	1
B	<50,000		4	4	1	1	
			6	10	2	2	
C	<200,000	4-6 Wks	10-14	10	8	2	4
C	>200,000	4-6 Wks	10-14	14	12	2	4
D	100,000 (modular)		2-4	8-10	2-12		
E	>100,000		4	14-16	10-12		
				12-14			

The average time for fabrication and construction of small electrostatic precipitators is about 37 weeks. Average time for larger units is about 46 weeks. These values represent conditions in the first quarter of 1973. As demand increases the elapsed time may also increase, but considerable variation among manufacturers would still be expected. Thus the expeditious schedules would still be reasonable, although the purchaser might have to contact more than one precipitator vendor to meet such a schedule.

Fabric Filters - Six vendors provided fabrication and construction times for fabric filters. Except for Vendor B, these figures are more consistent than those obtained for electrostatic precipitators. Construction time for fabric filters is about 18 weeks for small units and about 24 weeks for large units. Table 4.2 summarizes data provided by the vendors.

Wet Scrubbers - Schedules for delivery and construction of wet scrubbers, obtained from six vendors, are tabulated in Table 4.3. Since high-pressure fans on some installations could require long delivery time, several fan manufacturers were also contacted. Data obtained from these manufacturers are summarized in Table 4.4.

Excluding the data from Vendors A and B for small wet scrubbers, the average time for fabrication and erection of small

TABLE 4.3 VENDOR DELIVERY SCHEDULES FOR WET SCRUBBERS

Vendor	Equip. Size, CFM	Assembly Drawings	Fabrication Drawings	Equip. Delivery	Equip. Erection	Debugging	Testing
A	<50,000		4-5 Wks.	7 Wks.			
B	Small		2-4	7-11		1-2 Wks.	1-2 Wks.
B	Large		4-8 (Hi-Energy)	20-24		2-4	2-4
C	<80,000		4	14-16			
C	>80,000		6	16-20			
D	∼100,000			Vulcanized } 20 Wks.	∼1 Wk.		
D	Large			Rubber Lined } 30	∼2		
E	∼100,000		4	14-16 Wks.	3	2	
E	Large		4-6	14-16 Wks.	3	2	
F							
F				10-14 Wks.			

Table 4.4 VENDOR DELIVERY SCHEDULES FOR HIGH-PRESSURE FANS

Vendor	Equip. Size, CFM	Assembly Drawings	Fabrication Drawings	Equip. Delivery	Equip. Erection	Debugging	Testing
A	<40,000 &<15"SP		4 Wks.	10-14 Wks.[a]	1 Wk.		
A	>40,000 &>15"SP		4	14-18[a]	2		
B	>20,000 &>20"SP			6-10			
C	<100,000 &<24"SP		4-6	14-20			
C	>100,000 &>24"SP		6-8	18-24			
D			8	26			
D			8	26			

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[a] Special material or castings require additional time.

wet scrubbers is about 18 weeks. The average for large wet scrubbers is about 23 weeks. The average figures for fans are about 19 weeks for small units and 23 weeks for large high-pressure units.

Ancillary Equipment - Table 4.5 summarizes data obtained from vendors for waste-water treatment equipment and ancillaries for the air pollution control device.

4.1.2 Case Histories

Case-history data obtained from the vendors were compared with present quoted times for fabrication and construction. Because of the variability in quoted delivery times for electrostatic precipitators, emphasis was placed on obtaining information pertinent to precipitator installations.

In analysis of the case-history data, the highly variable and time-consuming activities, such as those preceding the award of contract and equipment tie-in, were separated from the activities of reasonably consistent durations, such as those from contract award to completion of construction. Times were then compared with the corresponding figures obtained from vendors for expected or projected schedules.

Table 4.5 VENDOR DELIVERY SCHEDULES FOR ANCILLARY EQUIPMENT

Source	Equipment	Size	Assembly Drawings	Drawings Approval	Delivery Time	Erection
A	Electric Motors	Large	4-5 Wks.	2 Wks.	15 Wks.	
	Electric Motors	1000 to 2500 HP	4-5	2	17	
A	Electric Transformers	Large Special	2-3	2	32	
	Electric Transformers	1500 KVA-TX	2-3	2	12-14	
A	Fans, High Volume, High SP	Spec. or Rubber Lined	8	2	~26	
B	Rotary Drum Filter	Carbon Steel	2	1	25-27	3 Wks.
	Rotary Drum Filter	Stainless Steel	2	1	27-29	3
B	Thickener	24' Dia.	2	1	21-23	2
	Thickener	75" Dia.	3	1	25-27	3
B	Centrifuge	Bowl Type	2	1	24	2

The case histories selected for evaluation are primarily those of single unit installations. Data on multiple unit installations were used after deducting the expected additional time required to complete construction of the additional units.

Values for the period "contract award to completion of construction" are plotted against electrostatic precipitator capacity in Figure 4.1. This graph shows a steep rise in the "contract award to completion of construction" time for small capacities up to about 300,000 CFM. Beyond that capacity, the rise is more gradual.

The average time from contract award to completion of construction for electrostatic precipitators with capacities lower than 300,000 CFM is 60 weeks. The average for units with capacities higher than 300,000 CFM is 80 weeks.

For purposes of comparison, two sets of lines are superimposed on Figure 4.1. One set, based on a summary of the quoted vendors data with regard to the time required for equipment fabrication and erection, shows 46 weeks for small electrostatic precipitators and 58 weeks for large units. The other sets of lines show the figures that were used to prepare the compliance schedules reflecting expeditious installation of electrostatic precipitators. These figures

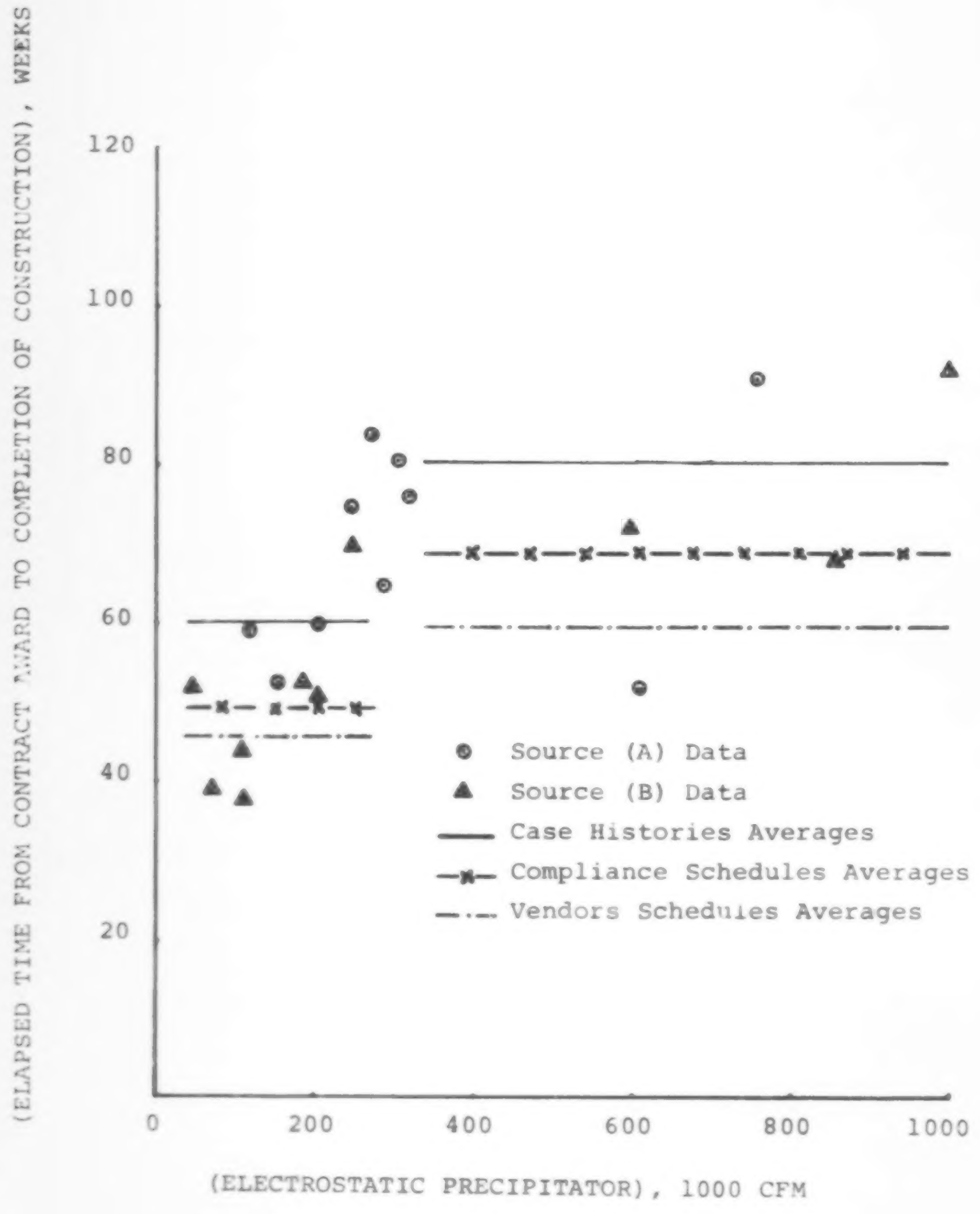


Figure 4.1 Case-history data
for electrostatic precipitators.

represent a compromise between the expected or projected schedules furnished by the vendors and actual time requirements found in the case histories, which were affected by contingencies and unforeseen delays.

The points on the graph also indicate that fabrication and construction of the electrostatic precipitators manufactured by the larger of the two companies required somewhat more time than the installations of the smaller company.

The limited case-history data obtained for installation of other types of control devices agreed substantially with figures cited by the vendors.

4.2 Industrial Contacts

Representatives from most of the industries studied were contacted to substantiate the information prepared for each industry with regard to operating practices, atmospheric emissions, and types of high-efficiency controls most commonly used and to ensure that control problems specific to that industry were not overlooked. The compliance schedules relating to installation of air pollution control devices for each type of industry operation were discussed. The persons contacted generally believe that the compliance schedules are reasonable if they are considered as representing the most expeditious cases.

Contacts with industry also yielded information on the practices of some companies in procuring control devices. Some examples are given below in terms of type of control device. These examples illustrate the inadequacy of case-history data alone as a basis for compliance schedules, since some installations are not performed in the most expeditious manner.

Wet Scrubbers - One large iron and steel manufacturer invites selected vendors to study the air pollution problem and to offer solutions based on use of their equipment. The sequence of activities, which the steel manufacturer considers as time required to obtain a proposal, is as follows:

Activity	Duration
1) Preliminary investigation, outline of process and problem	Several months
2) Request for engineering proposal from vendors including approach to problem and delivery time on equipment, but excluding price information	6 - 8 weeks
3) Review of proposal and approach to problem	4 weeks
4) Final engineering proposal (excluding price information)	6 - 8 weeks
5) Internal review and analysis	4 weeks
6) Meeting with bidders	4 weeks
7) Firm proposal preparation, including price information	6 - 12 weeks
8) Award of contract	2 - 3 weeks

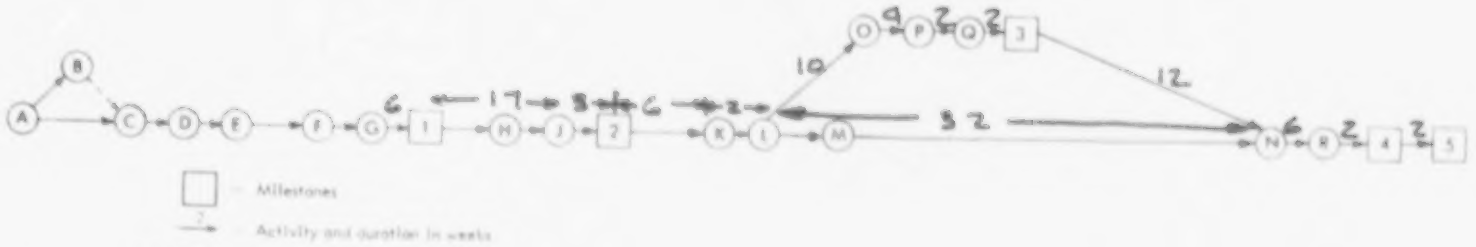
In this instance, a high-energy wet scrubber was selected to control particulate emissions from an open hearth furnace, an electric arc furnace, and a sintering plant.

Analysis of this sequence in terms of the compliance schedule for installation of large high-energy wet scrubbers shows that Steps 1, 2, and 3 above correspond to activities between A and G on the schedule. Step 4 is G-1, Steps 5, 6, and 7 are activity 1 to J, and Step 8 is J-2.

A composite compliance schedule made up partly of the above information, including delivery time of the controlling equipment (in this case the high pressure/through-put fan) and supplemented with reasonable times for the missing activities, indicated a compliance period of about 76 weeks; this is in line with the expeditious schedule prepared for large high energy scrubbers. Figure 4.2 summarizes the installation schedule.

Electrostatic Precipitator - A cement manufacturer supplied his projected schedule for installation of a custom electrostatic precipitator (300,000 CFM) on a cement kiln. At the time this information was presented, only Steps 1 and 2 were completed.

Figure 4.2 Schedule for installation of high energy wet scrubber on steel furnace.



MILESTONES

		ELAPSED TIME (WEEKS)
1	Date of submittal of final control plan to appropriate agency.	6
2	Date of award of control device contract.	26
3	Date of initiation of on-site construction or installation of emission control equipment.	52
4	Date by which on-site construction or installation of emission control equipment is completed.	74
5	Date by which final compliance is achieved.	76

ACTIVITIES

Designation		Designation	
A-C	Preliminary investigation	K-L	Review and approval of assembly drawings
A-B	Source tests	L-M	Vendor prepares fabrication drawings
C-D	Evaluate control alternatives	M-N	Fabricate control device
D-E	Commit funds for total program	L-O	Prepare engineering drawings
E-F	Prepare preliminary control plan and compliance schedule for agency	O-P	Procure construction bids
F-G	Agency review and approval	P-Q	Evaluate construction bids
G-1	Finalize plans and specifications	Q-3	Award construction contract
1-H	Procure control device bids	3-N	On-site construction
H-J	Evaluate control device bids	N-R	Install control device
J-2	Award control device contract	R-4	Complete construction (system tie-in)
2-K	Vendor prepares assembly drawings	4-5	Startup, shakedown, preliminary source test

Activity	Duration
1) Preliminary layout and preparation of bids specification	9 weeks
2) Procurement of control device bids	22 weeks[a]
3) Review of bids and award of contract	9 weeks
4) Vendor prepare assembly drawings	13 weeks[b]
5) Fabrication and delivery of first components to site	40 weeks
6) Construction, including tie-in time	36 weeks[c]
7) Startup, debugging, and emissions testing	14 weeks[d]

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[a] The reason given for this delay was noncompliance of the vendors with specifications. Twelve weeks of diligent effort would be more reasonable.

[b] Unusually long time for submission of assembly drawings (showing dimensions and weights). Eight weeks is more reasonable.

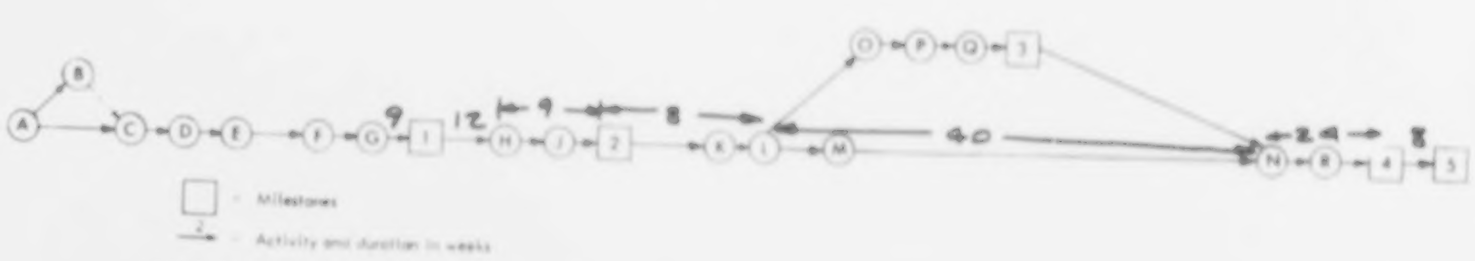
[c] A shorter duration of 24 weeks should be sufficient for expeditious schedules. Longer duration is due in part to cold winter months.

[d] Duration of eight weeks should be reasonable for start-up, debugging, and emissions testing.

A reasonable compliance schedule for this installation, including four weeks for finalization of plans, is shown in Figure 4.3.

Fabric Filters - A schedule for installation of a custom-designed 150,000 ACFM fabric filter on a large gray iron cupola is given below; it includes the time required to modify the charging mechanism to the two cupolas.

Figure 4.3 Schedule for installation of electrostatic precipitator on cement kiln.



MILESTONES

		ELAPSED TIME (WEEKS)
1	Date of submittal of final control plan to appropriate agency.	9
2	Date of award of control device contract.	30
3	Date of initiation of on-site construction or installation of emission control equipment.	
4	Date by which on-site construction or installation of emission control equipment is completed.	102
5	Date by which final compliance is achieved.	110

ACTIVITIES

Designation		Designation	
A-C	Preliminary investigation	K-L	Review and approval of assembly drawings
A-B	Source tests	L-M	Vendor prepares fabrication drawings
C-D	Evaluate control alternatives	M-N	Fabricate control device
D-E	Commit funds for total program	L-O	Prepare engineering drawings
E-F	Prepare preliminary control plan and compliance schedule for agency	O-P	Procure construction bids
F-G	Agency review and approval	P-Q	Evaluate construction bids
G-1	Finalize plans and specifications	Q-3	Award construction contract
1-H	Procure control device bids	3-N	On-site construction
H-J	Evaluate control device bids	N-R	Install control device
J-2	Award control device contract	R-4	Complete construction system tie-in
2-K	Vendor prepares assembly drawings	4-5	Startup, shakedown, preliminary source test

ACTIVITY	DURATION
1) Award of engineering contract	-
2) Completion of engineering and fabrication drawings	63 weeks[a]
3) Delivery of first material to site	14 weeks
4) Completion of construction and emission testing.	24 weeks

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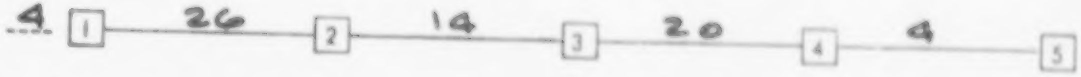
[a] Long duration partly due to backlog of work by the engineering company. Twenty-six weeks should be more than adequate for completion of this phase of the project.

A reasonable compliance schedule, including four weeks of finalization of plans, is shown in Figure 4.4.

Figure 4.4 Schedule for installation of custom designed fabric filter on gray iron cupola.



MILESTONES		ELAPSED TIME (WEEKS)
1	Date of submittal of final control plan to appropriate agency.	4
2	Date of award of control device contract.	30
3	Date of initiation of on-site construction or installation of emission control equipment.	44
4	Date by which on-site construction of emission control equipment is completed.	64
5	Date by which final compliance is achieved.	68

ACTIVITIES

DESIGNATIONS	
1 - 2	Preparation of detailed engineering and fabrication drawings, equipment specifications, construction bid documents and award of construction contract.
2 - 3	Equipment fabrication and delivery of structural components to site.
3 - 4	Delivery of remaining equipment and completion of construction including process tie in.
4 - 5	Equipment start up and source testing.